

DNA ENCODING A NOVEL RG1 POLYPEPTIDE

This application is a continuation-in-part application of U.S. Application

- 5 Serial No. 09/732,357, filed December 7, 2000, and claims the benefit of U.S. Provisional Application No. 60/172,370, filed December 16, 1999, which is incorporated herein in full by reference.

FIELD OF THE INVENTION

- 10 This invention relates, in part, to newly identified polynucleotides and polypeptides; variants and derivatives of the polynucleotides and polypeptides; methods of making the polynucleotides and polypeptides, and their variants and derivatives; antibodies directed toward the polypeptides, their variants and derivatives; and uses of the polynucleotides, polypeptides, variants, derivatives and antibodies. In particular, in these and in other regards, the invention relates to novel human extracellular matrix polypeptides (designated RG1), polynucleotides which encode these polypeptides, 15 antibodies directed toward these polypeptides, and antisense polynucleotides that block RG1 expression.

BACKGROUND OF THE INVENTION

- 20 Prostate cancer is a frequently occurring disease in man, in that it is found in about one third of men over the age of 45. There is evidence for both genetic and environmental causes, with the majority of cases probably being the result of a combination of both factors. Studies of familial cancer have suggested that genetic predisposition plays a role in about 5-10% of all prostate cancers, and in about 45% of cases in men younger than 55.

- 25 There is evidence that prostate cancer develops as a multi-step disease, with one of the precursor lesions being prostatic intraepithelial neoplasia (PIN). Early stages of the disease are androgen dependent, while later stages are hormone independent. A proliferative disorder of the prostate known as benign prostatic hyperplasia is often detected clinically but is probably not a stage in the development of cancer. It is, however, frequently associated with prostate cancer. Cancers in the prostate are often multifocal, generally slow growing, and heterogeneous. Late stage cancers 30 frequently metastasize to the lymph nodes and to the bone.

- Prostate cancer is usually diagnosed by physical examination and by serum levels of prostate specific antigen (PSA). Radical prostatectomy is the treatment of choice for localized disease. Advanced metastatic disease is treated currently by androgen ablation induced by orchiectomy or treatment with GnRH (gonadotrophin releasing hormone), and by anti-androgen therapy. However, 35 advanced disease almost invariably becomes hormone resistant and there is no cure for progressive disease. Moreover, there are serious side effects associated with both radical prostatectomy and androgen ablation therapy. These include a high risk of incontinence and impotence associated with

radical prostatectomy and bone fractures and osteoporosis associated with androgen ablation therapy.

There is, therefore, a considerable need for new therapeutic approaches for both early and late stage prostate cancer. There is also a significant need for new diagnostic agents, in particular agents that can discriminate stages of the disease, as this significantly influences the treatment options. For example, if disease has progressed beyond the prostate and has metastasized to the lymph nodes, radical prostatectomy is not undertaken as it has no effect on progression, but may have significant unwanted side effects. An agent that could detect metastasis, *in vivo*, would have considerable value.

Changes in the expression of specific proteins have been demonstrated in prostate cancer including abnormal p53 expression in late stage prostate cancer, reduced levels of TGF- β receptors, reduced levels of E-cadherin, C-Cam (a cell adhesion molecule), and several integrins. The expression of the oncogene bcl-2 is strikingly elevated in late stage androgen independent tumors, and prognosis for patients expression bcl-2 at elevated levels is relatively poor. While the previously mentioned changes in gene expression are well documented, no changes in expression have been identified that have been demonstrated to be causative for the disease. It would, therefore, be useful to identify new proteins whose expression is linked to the presence or development of prostate tumors that could serve as molecular targets for compositions directed to prostate cancer diagnosis and therapy.

This invention discloses a new homologue to a superfamily of extracellular matrix proteins. This homologue, named RG1 is expressed in both prostate tissue and in prostate tumors and metastasis.

The extracellular matrix is a complex meshwork of collagen and elastin, embedded in a viscoelastic ground substance composed of proteoglycans and glycoproteins. The matrix exists as a three dimensional supporting scaffold that isolates tissue compartments, mediates cell attachment and determines tissue architecture (Bissel et al., *J. Theor. Biol.* 99:31-68, 1982; Carlson et al., *Proc. Natl. Acad. Sci. USA* 78:2403-2406, 1981). The matrix acts as a macromolecular filter (Hay, E.D., *Cell Biology of Extracellular Matrix*, New York, Plenum Press, 1982) and also influences cytodifferentiation, mitogenesis, and morphogenesis (Gospodarowicz, D., *Cancer Res.* 38:4155-171, 1978). The biochemical interactions between normal cells and the matrix may be altered in neoplasia, and this may influence tumor proliferation. Tumor cells can interact with the matrix in different ways. First, tumor cells can attach to the matrix via specific plasma membrane receptors (Terranova et al., *Cancer Res.* 42:2265-2269, 1982). Second, degradation of the matrix is mediated by a cascade of enzymes that are contributed by the tumor cell and the host (Eisen et al., *Bioch. Biophys. Acta* 151:637-645, 1968). Third, in differentiated areas of the tumor, tumor cells may synthesize and accumulate matrix or induce the host cell to accumulate excessive matrix (Brownstein et al., *Cancer* 40: 2979-2986, 1977).

RG1 shows homology to a superfamily of extracellular matrix proteins, encoded by the Mindin/F-spondin genes. The gene family is united by two conserved spondin domains, FS1 and FS2, near the amino terminus and at least one thrombospondin type 1 repeat (TSR1) at the carboxy terminus (Shimeld, S.M., *Mol. Biol. Evol.* 15(9): 1218-1223, 1998). The TSR motif was originally found in the vertebrate extracellular matrix proteins (Bornstein, P., *J. Cell Biol.* 130:503-506, 1995) and has

subsequently been found in several other extracellular matrix proteins. There are several lines of evidence that TSR's mediate cell adhesion and play a key role in tumorigenesis. For example, it has been demonstrated that proteolytic fragments of thrombospondin that contain the TSR's, and synthetic peptides having sequences corresponding to the TSR region of thrombospondin, promote tumor cell adhesion and metastasis (Prater et al., *J. Cell Biol.* 112:1031-1040, 1991; Tuszynski and Nicosia, *BioEssays* 18:71-76, 1996), have anti-angiogenic activity (Tolsma et al., *J. Cell Biol.* 122:497-511, 1993) and inhibit platelet aggregation and melanoma metastasis (Tuszynski et al., *J. Cell Biol.* 116:209-217, 1992).

Currently, the members of this superfamily include a gene in *Caenorhabditis elegans*, a single gene in *Drosophila* and multiple genes in vertebrates. In *C. elegans*, the gene F10E7.4 encodes for five TSR's in addition to the FS1 and FS2 domains (Higashijima et.al., *Dev. Biol.* 192:211-227, 1997). In *Drosophila*, the family member termed M-spondin (mspo) contains the FS1 and FS2 domains and a single TSR (Umemiya et al., *Dev. Biol.* 186:165-176, 1997). The M-spondin gene encodes a secreted protein that is localized at the muscle attachment sites and seems to function as an extracellular matrix protein that supports muscle -apodeme attachment. The family members in vertebrates include genes isolated from zebrafish (Mandin1 and Mandin2, F-spondin1, and F-spondin2), rat F-spondin, *Xenopus* F-spondin and rat Mandin. Mandin1 and Mandin2 are closely related to each other and have a gene structure similar to that of *Drosophila* M-spondin. Both Mandin1 and Mandin2 genes encode for a single TSR in addition to the FS1 and FS2 domains (Higashijima et.al., *Dev. Biol.* 192:211-227, 1997). Zebrafish F-spondin1 and F-spondin2, rat F-spondin (Klar et al., *Cell* 69:95-110, 1992) and *Xenopus* F-spondin (Altaba et al., *Proc. Natl. Acad. Sci. USA* 90:8268-8272) genes all have similar structures, encoding six copies of the TSR's in addition to the FS1 and FS2 domains. In vertebrates, the Mandin/F-spondin superfamily can be classified into two groups: those genes closely related to the original rat F-spondin and Mandin genes and those genes closely related to the *Drosophila* M-spondin gene. Both vertebrate Mandin and F-spondin genes code for proteins that are primarily expressed by the floor plate of the neural tube during embryonic development.

Recently, a single F-spondin related gene, AmphiF-spondin, has been isolated from amphioxus (Shimeld, S.M., *Mol. Biol. Evol.* 15(9): 1218-1223, 1998). Based on molecular phylogenetics, AmphiF-spondin is closely related to a particular subgroup of vertebrate F-spondin genes that encode six TSR's. AmphiF-spondin encodes three TSR's and two fibronectin type III repeats, one of which has strong identity to a fibronectin type III repeat from Deleted in Colorectal Cancer (DCC). The expression of the protein is found through most of the central nervous system and is not confined to the midline as described for the vertebrate Mandin and F-spondin proteins.

These data suggest that extracellular matrix proteins, such as the novel RG1 protein, which is a homologue of the Mandin/F-spondin superfamily, would be good candidates for use in diagnosis of cancer and therapeutic intervention.

SUMMARY OF THE INVENTION

The present invention provides a polynucleotide sequence which uniquely encodes a novel protein designated herein as RG1. The RG1 polypeptide shows homology to the rat Mindin extracellular matrix protein. It contains a hydrophobic signal sequence at the N-terminus, two spondin domains (FS1 and FS2), and a thrombospondin type 1 repeat at its C-terminus. RG1 shows 89.7% similarity to rat Mindin. The polynucleotide sequence, designated herein as *rg1*, and described herein in Figure 1 (SEQ ID NO: 1), encodes the amino acid sequence for RG1, which is shown in Figure 2 (SEQ ID NO: 2).

Toward these ends, and others, it is an object of the present invention to provide polypeptides, inter alia, that have been identified as novel proteins with homology to the Mindin family of extracellular matrix proteins, as shown by comparison of the amino acid sequence set out in Figure 2 (SEQ ID NO: 2) and known amino acid sequences of other extracellular matrix proteins.

It is a further object of the invention, moreover, to provide polynucleotides that encode such polypeptides, particularly polynucleotides that encode the polypeptide designated herein as RG1.

In accordance with this aspect of the invention there are provided isolated polynucleotides encoding RG1, including mRNAs, cDNAs, and, in further embodiments of this aspect of the invention, biologically, diagnostically, clinically or therapeutically useful variants, analogs or derivatives thereof, or fragments thereof, including fragments of the variants, analogs and derivatives.

Among the particularly preferred embodiments of this aspect of the invention are naturally occurring allelic variants of polynucleotides that encode variants of the polypeptide designated herein as RG1.

In accordance with this aspect of the invention there are provided novel polypeptides of human origin referred to herein as RG1 as well as biologically, diagnostically or therapeutically useful fragments, variants and derivatives thereof, variants and derivatives of the fragments, and analogs of the foregoing.

Among the particularly preferred embodiments of this aspect of the invention are variants of RG1 encoded by naturally occurring allelic variants of the *rg1* polynucleotide.

It is another object of the invention to provide a method of producing the aforementioned polypeptides, polypeptide fragments, variants and derivatives, fragments of the variants and derivatives, and analogs of the foregoing. In a preferred embodiment of this aspect of the invention there are provided methods of producing the aforementioned RG1 polypeptides comprising culturing host cells having expressibly incorporated therein an exogenously-derived RG1-encoding polynucleotide under conditions for expression of human RG1 in the host and then recovering the expressed polypeptide.

In accordance with another object of the invention there are provided products, compositions, processes and methods that utilize the aforementioned polypeptides and polynucleotides for *inter alia* research, biological, clinical and therapeutic purposes.

In accordance with certain preferred embodiments of this aspect of the invention, there are provided products, compositions and methods, *inter alia*, for assessing RG1 expression in cells by determining RG1 polypeptides or RG1-encoding mRNA; and assaying genetic variation and aberrations, such as defects, in *rg1* genes.

5 In accordance with certain preferred embodiments of this and other aspects of the invention there are provided probes that hybridize to *rg1* sequences.

It is a further object of the invention to provide isolated antibodies, or antigen-binding antibody fragments thereof, or variants thereof, that specifically bind to an epitope present in an RG1 polypeptide (SEQ ID NO: 2). Particularly preferred are human antibodies that bind to epitope of the RG1
10 polypeptide with a dissociation constant (K_D) which is less than or equal to 1 μ M, more preferably less than or equal to 100 nM and most preferably less than or equal to 10 nM.

In accordance with further preferred embodiments of the invention, isolated antibodies and antigen-binding antibody fragments thereof, comprising a light chain variable region comprising the amino acid sequences of SEQ ID NO: 26 or SEQ ID NO: 29 are provided.

15 Also provided are isolated antibodies and antigen-binding antibody fragments thereof, comprising a heavy chain variable region comprising the amino acid sequences SEQ ID NO: 27, SEQ ID NO: 28, SEQ ID NO: 30 or SEQ ID NO: 31. A particularly preferred embodiment is a human antibody, comprising a light chain variable region having the amino acid sequence SEQ ID NO: 26 and a heavy chain variable region having the amino acid sequence SEQ ID NO: 27 or SEQ ID NO: 28. A
20 second particularly preferred embodiment is a human antibody, comprising a light chain variable region having the amino acid sequence SEQ ID NO: 29 and a heavy chain variable region having the amino acid sequence SEQ ID NO: 30 or SEQ ID NO: 31.

In a further aspect of the invention, light chain variable regions and heavy chain variable regions with amino acid sequences having 80% sequence identity to the amino acid sequences described
25 above are also contemplated.

Also provided are nucleotide sequences which encode the light chain and heavy chain variable regions of the antibodies described above. Preferred is an antibody comprising a light chain variable region encoded by a nucleotide sequence comprising SEQ ID NO: 20 or SEQ ID NO: 23. Also preferred is an antibody comprising a heavy chain variable region encoded by a nucleotide sequence
30 comprising SEQ ID NO: 21, SEQ ID NO: 22, SEQ ID NO: 24, or SEQ ID NO: 25.

In accordance with certain preferred embodiments of this aspect of the invention, the antibodies are conjugated to a detectable marker, for use as a diagnostic agent for administration to cells *in vitro*, to cells *ex vivo* and to cells *in vivo*, or to a multicellular organism. Particularly preferred would be an antibody conjugated to a radiolabel, an enzyme, a chromophore or a fluorescer. Particularly preferred
35 methods of detection are immunoscintigraphy and positron emitting tomography, in which the antibody would be conjugated to a radioisotope such as ^{111}In or $^{99\text{m}}\text{Tc}$, for immunoscintigraphy, or to ^{43}Sc , ^{44}Sc , ^{52}Fe , ^{55}Co , ^{68}Ga , ^{64}Cu , ^{86}Y or $^{94\text{m}}\text{Tc}$, for positron emitting tomography.

In a further aspect of the invention there are provided antibodies that are conjugated to a therapeutic agent, e.g. ricin or a radioisotope, for administration to cells *in vitro*, to cells *ex vivo* and to cells *in vivo*, or to a multicellular organism. Preferred in this regard are therapeutic agents that are cytotoxic. Particularly preferred for a therapeutic agent would be antibodies conjugated to a radioisotope, such as ^{90}Y and ^{177}Lu . In certain preferred embodiments in this regard is administration of such conjugated antibodies to a human patient for treatment of a disease state characterized by RG1 expression, such as prostate cancer, and in particular, advanced metastatic prostate cancer.

In a further aspect of the invention, conjugation of an RG1 antibody, or antigen-binding fragment thereof, to a detectable marker or cytotoxic agent is accomplished through use of a chelator selected from the group consisting of p-SCN-Benzyl-DPTA and derivatives thereof, 1, 4, 7, 10-tetraazacyclododecane-N, N', N'', N'''-tetracetic acid (DOTA) and derivatives thereof, and 1,4,7-triazacyclononane-N, N', N''-triacetic acid (NOTA) and derivatives thereof.

In a further aspect of the invention is a method for treatment of a disease-state associated with expression of an RG1 polypeptide, such as prostate cancer, which uses the immunoconjugates of the present invention.

In a further aspect of the invention is a method for detection of a disease-state associated with expression of an RG1 polypeptide, such as prostate cancer, which uses the immunoconjugates of the present invention.

In a further aspect of the invention, peptides and anti-idiotypic antibodies are provided which can be used to stimulate an immune response.

In a further aspect of the invention there are provided ribozymes and polynucleotides complementary to *rg1* polynucleotides (i.e. antisense polynucleotides) for administration to cells *in vitro*, to cells *ex vivo* and to cells *in vivo*, or to a multicellular organism. Particularly preferred in this regard is administration of antisense molecules to a human patient for treatment of a disease state, such as prostate cancer or benign prostatic hyperplasia, which is alleviated by decreasing the level of RG1 activity.

Other objects, features, advantages and aspects of the present invention will become apparent to those of skill from the following description. It should be understood, however, that the following description and the specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only. Various changes and modifications within the spirit and scope of the disclosed invention will become readily apparent to those skilled in the art from reading the following description and from reading the other parts of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1: Polynucleotide sequence of *rg1* (SEQ ID NO: 1), which encodes the biologically or immunologically active form of RG1.

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FIGURE 2: Deduced amino acid sequence of RG1 (SEQ ID NO: 2), with the F-spondin domains single underlined, and the thrombospondin domain double underlined.

FIGURE 3: Amino acid alignment of RG1 (SEQ ID NO: 2) with the sequence of rat Mindin (SEQ ID NO: 13). The sequence of RG1 (SEQ ID NO: 2) is on the top.

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FIGURE 4: Polynucleotide (SEQ ID NO: 1) and deduced amino acid (SEQ ID NO: 2) sequences of RG1.

FIGURE 5: Expression of *rg1* mRNA in human tissues by Taqman based PCR analysis. RNA from human tissues, both tumor and normal, was isolated by standard techniques. Primers and probe to detect *rg1* mRNA expression were designed using Perkin Elmer's Primer Express software and synthesized by Synthetic Genetics. *Rg1* mRNA was detected in human prostate tissues. A much lower expression of *rg1* mRNA could be detected in other tissues; e.g. liver.

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FIGURE 6: Purification of native RG1 protein secreted by LNCaP cells. Western blot analysis, using antisera generated against a synthetic RG1 peptide sequence (3C, SEQ ID NO: 10; see Example 4), to detect native RG1 protein secreted from LNCaP cells. Elution fractions from Q-Sepharose chromatography of concentrated LNCaP cell conditioned media: (L) column load, (F) column flow-thru, (1-12) elution fractions across salt gradient. The predicted molecular weight of RG1 is ~36 kD, however the bacterially expressed RG1, BHK-expressed RG1 and the LNCaP-expressed RG1 protein all have been observed to migrate at ~45 kD on PAGE (L, fractions 6-9).

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FIGURE 7: Biodistribution of ¹¹¹In labeled RG1 Antibodies: Three RG1 antibodies (A, B, and C), a non-specific hIgG₁ control antibody, and Prostascint™ were radiolabeled with ¹¹¹In. Radiolabeled antibodies (specific activity: 0.3 mCi/mg) were administered i.v. into tumor (LNCaP) bearing nude mice. Twelve animals per group (3 animals per time point) were sacrificed at 6, 24, 120, and 150 hr p.i. and the accumulation in the tumor, blood and liver monitored. (See Example 11)

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FIGURE 8: Anti-tumor effect of ⁹⁰Y labeled RG1 Antibodies: LNCaP tumor bearing animals were injected with ⁹⁰Y labeled antibodies (RG1 antibodies B and C or non-specific IgG₁, specific activity, 0.5 mCi/mg). A single dose of 125 μCi ⁹⁰Y-labeled RG1 antibody (B, C) was administered i.p. Mice

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were sacrificed at day 32 and tumors excised and weighed. (See Example 12)

FIGURE 9: Amino acid sequence of the variable chain regions of human monoclonal antibody B, including a mutated variable heavy chain region. V_L (SEQ ID NO: 26), V_H (SEQ ID NO: 27), V_{H_2m} (SEQ ID NO: 28).

FIGURE 10: Amino acid sequence of the variable chain regions of human monoclonal antibody C, including a mutated variable heavy chain region. V_L (SEQ ID NO: 29), V_H (SEQ ID NO: 30), V_{H_3m} (SEQ ID NO: 31).

DETAILED DESCRIPTION OF THE INVENTION

Definitions

As used in the specification, examples and appended claims, unless specified to the contrary, the following terms have the meaning indicated.

"*rg1*" refers to the polynucleotide having the sequence set out in Figure 1 (SEQ ID NO: 1) and polynucleotides encoding polypeptides having the amino acid sequence of RG1 set out in Figure 2 (SEQ ID NO: 2); and to polynucleotides encoding RG1 variants, derivatives and fragments, and fragments of the variants and derivatives. *Rg1* also refers to such polynucleotides composed of RNA as well as to polynucleotides which are the complement of polynucleotides which encode the polypeptide sequence set out in Figure 2 (SEQ ID NO: 2).

"RG1" refers to the polypeptide having the amino acid sequence set out in Figure 2 (SEQ ID NO: 2), variants and derivatives thereof, and fragments of SEQ ID NO: 2, variants and derivatives thereof. The terms "variant", "fragment" and "derivative", when referring to the polypeptide of Figure 2 (SEQ ID NO: 2) mean a polypeptide which retains essentially the same biologic and/or immunologic activity as the polypeptide of Figure 2 (SEQ ID NO: 2).

"Biologic activity" refers to the structural, regulatory or biochemical functions of naturally occurring RG1 polypeptide.

"Immunologic activity" refers to (1) the capability of the natural, recombinant or synthetic RG1, or any fragment thereof, to induce a specific immune response in appropriate animals or cells and to bind with specific antibodies, or (2) the capacity of antibodies to RG1 to bind RG1 *in vivo* and trigger an enhanced, cellular immune response to RG1 expressing tissue or tumor.

"Naturally occurring RG1" refers to RG1 produced by human cells that have not been genetically engineered and specifically contemplates various RG1 forms arising from post-translational modifications of the polypeptide including but not limited to acetylation, carboxylation, glycosylation,

phosphorylation, lipidation, acylation, and cleavage.

"Native RG1" or "nRG1" refers to RG1 which is in its native conformation.

"Polynucleotide(s)" generally refers to any polyribonucleotide or polydeoxribonucleotide, which may be unmodified RNA or DNA or modified RNA or DNA. Thus, for instance, polynucleotides as used herein refers to, among others, single- and double-stranded DNA, DNA that is a mixture of single- and double-stranded regions, single- and double-stranded RNA, and RNA that is mixture of single- and double-stranded regions, hybrid molecules comprising DNA and RNA that may be single-stranded or, more typically, double-stranded or a mixture of single- and double-stranded regions. In addition, polynucleotide as used herein refers to triple-stranded regions comprising RNA or DNA or both RNA and DNA. The strands in such regions may be from the same molecule or from different molecules. The regions may include all of one or more of the molecules, but more typically involve only a region of some of the molecules. One of the molecules of a triple-helical region often is an oligonucleotide.

As used herein, the term "polynucleotide" includes DNAs or RNAs as described above that contain one or more modified bases. Thus, DNAs or RNAs with backbones modified for stability or for other reasons are "polynucleotides" as that term is intended herein. Moreover, DNAs or RNAs comprising unusual bases, such as inosine, or modified bases, such as tritium-labelled bases, to name just two examples, are polynucleotides as the term is used herein.

It will be appreciated that a great variety of modifications have been made to DNA and RNA that serve many useful purposes known to those of skill in the art. The term "polynucleotide" as it is employed herein embraces such chemically, enzymatically or metabolically modified forms of polynucleotides, as well as the chemical forms of DNA and RNA characteristic of viruses and cells, including simple and complex cells, *inter alia*.

"Oligonucleotide(s)" refers to relatively short polynucleotides. Often the term refers to single-stranded deoxyribonucleotides, but it can refer as well to single- or double-stranded ribonucleotides, RNA:DNA hybrids and double-stranded DNAs, among others. Oligonucleotides, such as single-stranded DNA probe oligonucleotides, often are synthesized by chemical methods, such as those implemented on automated oligonucleotide synthesizers. However, oligonucleotides can be made by a variety of other methods, including *in vitro* recombinant DNA-mediated techniques and by expression of DNAs in cells and organisms. "Oligonucleotides" or "oligomers" or polynucleotide "fragment", "portion", or "segment" refers to a polynucleotide sequence of at least about 10 nucleotides and as many as about 60 nucleotides, preferably about 15 to 30 nucleotides, and more preferably about 20-25 nucleotides.

"Polypeptides", as used herein, includes all polypeptides as described below. The basic structure of polypeptides is well known and has been described in innumerable textbooks and other publications in the art. In this context, the term is used herein to refer to any peptide or protein comprising two or more amino acids joined to each other in a linear chain by peptide bonds. As used herein, the term refers to both short chains, which also commonly are referred to in the art as peptides, oligopeptides and oligomers, for example, and to longer chains, which generally are referred to in the art

as proteins, of which there are many types.

It will be appreciated that polypeptides often contain amino acids other than the 20 amino acids commonly referred to as the 20 naturally occurring amino acids, and that many amino acids, including the terminal amino acids, may be modified in a given polypeptide, either by natural processes such as glycosylation and other post-translational modifications, or by chemical modification techniques which are well known in the art. Common modifications include glycosylation, lipid attachment, sulfation, gamma-carboxylation of glutamic acid residues, hydroxylation and ADP-ribosylation, and these and others are described in most basic texts, such as, for instance, I. E. Creighton, *Proteins-Structure and Molecular Properties*, 2nd Ed., W.H. Freeman and Company, New York, 1993. Many detailed reviews are available on this subject, such as, for example, those provided by Wold, F., in *Posttranslational Covalent Modification of Proteins*, B. C. Johnson, Ed., Academic Press, New York, pp 1-12, 1983; Seifter et al., *Meth. Enzymol.* 182: 626-646, 1990 and Rattan et al., *Protein Synthesis: Posttranslational Modifications and Aging*, Ann. N.Y. Acad. Sci. 663: 48-62, 1992.

It will be appreciated, as is well known, and as noted above, that polypeptides are not always entirely linear. For instance, polypeptides may be branched as a result of ubiquitination, and they may be circular, with or without branching, generally as a result of posttranslational events, including natural processing events and events brought about by human manipulation which do not occur naturally. Circular, branched and branched circular polypeptides may be synthesized by non-translational natural processes and by entirely synthetic methods, as well.

Modifications can occur anywhere in a polypeptide, including the peptide backbone, the amino acid side-chains and the amino or carboxyl termini. In fact, blockage of the amino or carboxyl group in a polypeptide, or both, by a covalent modification, is common in naturally occurring and synthetic polypeptides and such modifications may be present in polypeptides of the present invention, as well. For instance, the amino terminal residue of polypeptides made in *E. coli*, prior to proteolytic processing, almost invariably will be N-formylmethionine.

The modifications that occur in a polypeptide often will be a function of how it is made. For polypeptides made by expressing a cloned gene in a host, for instance, the nature and extent of the modifications in large part will be determined by the host cell posttranslational modification capacity and the modification signals present in the polypeptide amino acid sequence. For instance, as is well known, glycosylation often does not occur in bacterial hosts such as *E. coli*. Accordingly, when glycosylation is desired, a polypeptide should be expressed in a glycosylating host, generally a eukaryotic cell. Insect cells often carry out the same posttranslational glycosylations as mammalian cells and, for this reason, insect cell expression systems have been developed to efficiently express mammalian proteins having native patterns of glycosylation, *inter alia*. Similar considerations apply to other modifications.

In general, as used herein, the term polypeptide encompasses all such modifications, particularly those that are present in polypeptides synthesized by expressing a polynucleotide in a host

cell.

"Derivative" refers to polynucleotides or polypeptides derived from naturally occurring *rg1*, RG1, or from antibodies binding RG1, respectively, by chemical modifications such as ubiquitination, labeling (e.g., with radionuclides, various enzymatic modifications), pegylation (derivatization with polyethylene glycol) or by insertion or substitution of amino acids such as ornithine (or substitution of the nucleotides which code for such as an amino acid), which do not normally occur in human proteins.

"Polynucleotide encoding a polypeptide" as used herein encompasses polynucleotides which include a sequence encoding a polypeptide of the present invention, particularly the RG1 polypeptide having the amino acid sequence set out in Figure 2 (SEQ ID NO: 2). The term encompasses polynucleotides that include a single continuous region or discontinuous regions encoding the polypeptide (for example, interrupted by introns) together with additional regions.

A polypeptide "fragment", "portion", or "segment" is a stretch of amino acid residues of at least about 5 amino acids, often at least about 7 amino acids, typically at least about 9 to 13 amino acids, and in various embodiments, at least about 17 or more amino acids. "Fragment" refers to a polypeptide having an amino acid sequence that is entirely the same as part, but not all, of the amino acid sequence of the aforementioned RG1 polypeptides, or antibodies to RG1, and variants or derivatives thereof.

"Deletion" is defined as a change in either polynucleotide or amino acid sequences in which one or more polynucleotides or amino acid residues, respectively, are absent.

"Insertion" or "addition" is that change in a polynucleotide or amino acid sequence which has resulted in the addition of one or more polynucleotides or amino acid residues, respectively, as compared to the naturally occurring polynucleotide or amino acid sequence.

"Substitution" results from the replacement of one or more polynucleotides or amino acids by different polynucleotides or amino acids, respectively.

"Variant(s)" of polynucleotides or polypeptides, as the term is used herein, are described below and elsewhere in the present disclosure in greater detail.

A variant of a polynucleotide is a polynucleotide that differs in polynucleotide sequence from another, reference polynucleotide. Generally, differences are limited so that the polynucleotide sequences of the reference and the variant are closely similar overall and, in many regions, identical.

Changes in the polynucleotide sequence of the variant may be silent. That is, they may not alter the amino acids encoded by the polynucleotide. Where alterations are limited to silent changes of this type a variant will encode a polypeptide with the same amino acid sequence as the reference. Also as noted below, changes in the polynucleotide sequence of the variant may alter the amino acid sequence of a polypeptide encoded by the reference polynucleotide. Such polynucleotide changes may result in amino acid substitutions, additions, deletions, fusions and truncations in the polypeptide encoded by the reference sequence, as discussed below.

A variant of a polypeptide is a polypeptide that differs in amino acid sequence from another, reference polypeptide. Generally, differences are limited so that the sequences of the reference and the

variant are closely similar overall and, in many regions, identical. A variant and reference polypeptide may differ in amino acid sequence by one or more substitutions, additions, deletions, fusions and truncations, which may be present in any combination. Recombinant variants encoding these same or similar polypeptides may be synthesized or selected by making use of the "redundancy" in the genetic code.

- 5 Various codon substitutions, such as the silent changes that produce various restriction sites, may be introduced to optimize cloning into a plasmid or viral vector or expression in a particular prokaryotic or eukaryotic system. Mutations may also be introduced to modify the properties of the polypeptide, to change ligand-binding affinities, interchain affinities, or polypeptide degradation or turnover rate.

As discussed herein, minor variations in the amino acid sequences of polypeptides, antibodies or immunoglobulin molecules are contemplated as being encompassed by the present invention, providing that the variations in the amino acid sequence maintain at least 80%, more preferably at least 85%, 90%, 95%, and most preferably 99% of the original sequence. In particular, conservative amino acid replacements are contemplated. Conservative replacements are those that take place within a family of amino acids that are related in their side chains. Genetically encoded amino acids are generally divided into families: (1) acidic (aspartate, glutamate); (2) basic (lysine, arginine, histidine); (3) non-polar (alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan); and (4) uncharged polar (glycine, asparagine, glutamine, cysteine, serine, threonine, tyrosine). More preferred families are: serine and threonine are an aliphatic-hydroxy family; asparagine and glutamine are an amide-containing family; alanine, valine, leucine and isoleucine are an aliphatic family; and phenylalanine, tryptophan, and tyrosine are an aromatic family. For example, it is reasonable to expect that an isolated replacement of a leucine with an isoleucine or valine, an aspartate with a glutamate, a threonine with a serine, or a similar replacement of an amino acid with a structurally related amino acid will not have a major effect on the binding or properties of the resulting molecule, especially if the replacement does not involve an amino acid within a framework site. Whether an amino acid change results in a functional peptide can readily be determined by comparing the specific activity of the polypeptide derivative with the unmodified polypeptide. For purposes of this application, the invention encompasses variants of the claimed antibodies which maintain a binding affinity (K_D) less than 1 μ M for an RG1 epitope.

The following terms are used to describe the sequence relationships between two or more polynucleotide or amino acid sequences: "reference sequence", "comparison window", "sequence identity", "percentage of sequence identity", "substantial identity", "similarity", and "homologous". A "reference sequence" is a defined sequence used as a basis for a sequence comparison; a reference sequence may be a subset of a larger sequence, for example, as a segment of a full-length cDNA or gene sequence given in a sequence listing or may comprise a complete cDNA or gene sequence. Generally, a reference sequence is at least 18 nucleotides or 6 amino acids in length, frequently at least 24 nucleotides or 8 amino acids in length, and often at least 48 nucleotides or 16 amino acids in length. Since two polynucleotides or amino acid sequences may each (1) comprise a sequence (i.e., a portion of the complete polynucleotide or amino acid sequence) that is similar between the two molecules, and

(2) may further comprise a sequence that is divergent between the two polynucleotides or amino acid sequences, sequence comparisons between two (or more) molecules are typically performed by comparing sequences of the two molecules over a "comparison window" to identify and compare local regions of sequence similarity. A "comparison window", as used herein, refers to a conceptual segment of at least 18 contiguous nucleotide positions or 6 amino acids wherein a polynucleotide sequence or amino acid sequence may be compared to a reference sequence of at least 18 contiguous nucleotides or 6 amino acid sequences and wherein the portion of the polynucleotide sequence in the comparison window may comprise additions, deletions, substitutions, and the like (i.e., gaps) of 20 percent or less as compared to the reference sequence (which does not comprise additions or deletions) for optimal alignment of the two sequences. Optimal alignment of sequences for aligning a comparison window may be conducted by the local homology algorithm of Smith and Waterman, *Adv. Appl. Math.* 2:482 (1981), by the homology alignment algorithm of Needleman and Wunsch, *J. Mol. Biol.* 48:443 (1970), by the search for similarity method of Pearson and Lipman, *Proc. Natl. Acad. Sci. (U.S.A.)* 85:2444 (1988), by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package Release 7.0, (Genetics Computer Group, 575 Science Dr., Madison, Wis.), Geneworks, or MacVector software packages), or by inspection, and the best alignment (i.e., resulting in the highest percentage of homology over the comparison window) generated by the various methods is selected.

The term "sequence identity" means that two polynucleotide or amino acid sequences are identical (i.e., on a nucleotide-by-nucleotide or residue-by-residue basis) over the comparison window. The term "percentage of sequence identity" is calculated by comparing two optimally aligned sequences over the window of comparison, determining the number of positions at which the identical nucleic acid base (e.g., A, T, C, G, U, or I) or residue occurs in both sequences to yield the number of matched positions, dividing the number of matched positions by the total number of positions in the comparison window (i.e., the window size), and multiplying the result by 100 to yield the percentage of sequence identity. The terms "substantial identity" as used herein denotes a characteristic of a polynucleotide or amino acid sequence, wherein the polynucleotide or amino acid comprises a sequence that has at least 85 percent sequence identity, preferably at least 90 to 95 percent sequence identity, more usually at least 99 percent sequence identity as compared to a reference sequence over a comparison window of at least 18 nucleotide (6 amino acid) positions, frequently over a window of at least 24-48 nucleotide (8-16 amino acid) positions, wherein the percentage of sequence identity is calculated by comparing the reference sequence to the sequence which may include deletions or additions which total 20 percent or less of the reference sequence over the comparison window. The reference sequence may be a subset of a larger sequence. The term "similarity", when used to describe a polypeptide, is determined by comparing the amino acid sequence and the conserved amino acid substitutes of one polypeptide to the sequence of a second polypeptide. The term "homologous", when used to describe a polynucleotide, indicates that two polynucleotides, or designated sequences thereof, when optimally aligned and

compared, are identical, with appropriate nucleotide insertions or deletions, in at least 70% of the nucleotides, usually from about 75% to 99%, and more preferably at least about 98 to 99% of the nucleotides.

"Antibody" or "antigen-binding antibody fragment" refers to an intact antibody, or a fragment thereof, that competes with the intact antibody for specific binding. An antibody or antigen-binding antibody fragment, is said to specifically bind an antigen when the dissociation constant is less than or equal to 1 μ M, preferably less than or equal to 100 nM and most preferably less than or equal to 10 nM. Binding can be measured by methods known to those skilled in the art, an example being the use of a BIAcoreTM instrument. Antibody fragments comprise a portion of an intact antibody, preferably the antigen binding or variable region of the intact antibody. Binding fragments include Fab, Fab', F(ab')₂, and Fv fragments; diabodies; linear antibodies; single-chain antibody molecules; and multispecific antibodies formed from antibody fragments (C. A. K Borrebaeck, editor (1995) *Antibody Engineering (Breakthroughs in Molecular Biology)*, Oxford University Press; R. Kontermann & S. Duebel, editors (2001) *Antibody Engineering* (Springer Laboratory Manual), Springer Verlag). An antibody other than a "bispecific" or "bifunctional" antibody is understood to have each of its binding sites identical.

"Epitope" includes any protein determinant capable of specific binding to an immunoglobulin or T-cell receptor. Epitopic determinants usually consist of chemically active surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics. Two antibodies are said to "bind the same epitope" if one antibody is shown to compete with the second antibody in a competitive binding assay, by any of the methods well known to those of skill in the art.

"Recombinant" or "recombinant DNA molecule" refers to a polynucleotide sequence which is not naturally occurring, or is made by the artificial combination of two otherwise separated segments of sequence. By "recombinantly produced" is meant artificial combination often accomplished by either chemical synthesis means, or by the artificial manipulation of isolated segments of polynucleotides, e.g., by genetic engineering techniques. Such manipulation is usually done to replace a codon with a redundant codon encoding the same or a conservative amino acid, while typically introducing or removing a sequence recognition site. Alternatively, it is performed to join together polynucleotide segments with desired functions to generate a single genetic entity comprising a desired combination of functions not found in the common natural forms. Restriction enzyme recognition sites, regulation sequences, control sequences, or other useful features may be incorporated by design. "Recombinant DNA molecules" include cloning and expression vectors. "Recombinant" may also refer to a polynucleotide which encodes a polypeptide and is prepared using recombinant DNA techniques.

"Isolated" means altered "by the hand of man" from its natural state; i.e., that, if it occurs in nature, it has been changed or removed from its original environment, or both. For example, a naturally occurring polynucleotide or a polypeptide naturally present in a living animal in its natural state is not "isolated", but the same polynucleotide or polypeptide separated from the coexisting materials of its

natural state is "isolated", as the term is employed herein. For example, with respect to polynucleotides, the term isolated means that it is separated from the chromosome and cell in which it naturally occurs. Polynucleotides and polypeptides may occur in a composition, such as media formulations, solutions for introduction of polynucleotides or polypeptides, for example, into cells, compositions or solutions for chemical or enzymatic reactions, for instance, which are not naturally occurring compositions, and, therein remain isolated polynucleotides or polypeptides within the meaning of that term as it is employed herein.

"Substantially pure" and "substantially homogenous" are used interchangeably and describe RG1 polypeptide, or fragments thereof, or a polynucleotide segment encoding same, where such polypeptide or polynucleotide is separated from components that naturally accompany it. An RG1 polypeptide or fragment thereof, or DNA segment encoding same is substantially free of naturally-associated components when it is separated from the native contaminants which accompany it in its natural state. Thus, a polypeptide that is chemically synthesized or synthesized in a cellular system different from the cell in which it naturally originates will be substantially free from its naturally-associated components. Similarly, a polynucleotide that is chemically synthesized or synthesized in a cellular system different from the cell in which it naturally originated will be substantially free from its naturally-associated components.

"Polymerase chain reaction" or "PCR" refers to a procedure wherein specific pieces of DNA are amplified as described in U.S. Pat. No. 4,683,195, issued 28 July 1987. Generally, sequence information from the ends of the polypeptide fragment of interest or beyond needs to be available, such that oligonucleotide primers can be designed; these primers will point towards one another, and will be identical or similar in sequence to opposite strands of the template to be amplified. The 5' terminal nucleotides of the two primers will coincide with the ends of the amplified material. PCR can be used to amplify specific DNA sequences from total genomic DNA, cDNA transcribed from total cellular RNA, plasmid sequences, etc. (See generally Mullis et al., *Cold Spring Harbor Symp. Quant. Biol.*, 51: 263, 1987; Erlich, ed., *PCR Technology*, Stockton Press, NY, 1989).

"Stringency" typically occurs in a range from about T_m (melting temperature)-5°C (5° below the T_m of the probe) to about 20°C to 25°C below T_m . As will be understood by those of skill in the art, a stringent hybridization can be used to identify or detect identical polynucleotide sequences or to identify or detect similar or related polynucleotide sequences. As herein used, the term "stringent conditions" means hybridization will occur only if there is at least 95% and preferably at least 97% identity between the sequences.

"Hybridization" as used herein, shall include "any process by which a polynucleotide strand joins with a complementary strand through base pairing" (Coombs, J., *Dictionary of Biotechnology*, Stockton Press, New York, N.Y., 1994).

"Therapeutically effective dose" refers to that amount of polypeptide or its antibodies, antagonists, or inhibitors, including antisense molecules and ribozymes, which ameliorate the symptoms or conditions of a disease state. A dose is considered a therapeutically effective dose in the treatment

of cancer or its metastasis when tumor or metastatic growth is slowed or stopped, or the tumor or metastasis is found to shrink in size, so as to lead to an extension in life span for the subject. A dose is also considered therapeutically effective if it leads to an improvement in the overall quality of life of the patient, i.e. alleviation of pain. Therapeutic efficacy and toxicity of such compounds can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, e.g., ED₅₀ (the dose therapeutically effective in 50% of the population) and LD₅₀ (the dose lethal to 50% of the population). The dose ratio between therapeutic and toxic effects is the therapeutic index, and it can be expressed as the ratio, ED₅₀/LD₅₀.

"Treating" or "treatment" as used herein covers the treatment of a disease-state in a human patient, which disease-state includes disease states which are characterized by an increased level of RG1, such as prostate cancer or advanced metastatic prostate cancer.

Detailed Description of the Invention

The present invention relates to novel RG1 polypeptides, *rg1* polynucleotides, and antibodies directed toward RG1 polypeptides, among other things, as described in greater detail below. In particular, the invention relates to novel RG1 polypeptides and the polynucleotides encoding these RG1 polypeptides, and relates especially to RG1 having the amino acid sequence set out in Figure 2 (SEQ ID NO: 2) and *rg1* having the polynucleotide sequence set out in Figure 1 (SEQ ID NO: 1). The present invention also encompasses RG1 variants. A preferred RG1 variant is one having at least 70% similarity (preferably at least 70% identity) to the polypeptide sequence shown in Figure 2 (SEQ ID NO: 2) and more preferably at least 90% similarity (more preferably at least 90% identity) to the polypeptide shown in Figure 2 (SEQ ID NO: 2) and still more preferably at least 95% similarity (still more preferably at least 95% identity) to the polypeptide sequence shown in Figure 2 (SEQ ID NO: 2) and also includes portions of such polypeptides with such portion of the polypeptide generally containing at least 30 amino acids and more preferably at least 50 amino acids.

The coding sequence for the predicted RG1 polypeptide begins 296 base pairs from the 5' end of the nucleotide sequence shown in Fig 1 (SEQ ID NO: 1). RG1 contains three structural domains characteristic of Mindin/F-spondin superfamily of extracellular matrix proteins: two spondin domains (FS1 and FS2), comprising amino acids 31 to 103 and 138 to 221, respectively, and a thrombospondin domain, comprising amino acids 278 to 330.

The present invention is based in part on the structural homology shown in Figure 3 between RG1 and rat Mindin, another member of the extracellular matrix protein family. The amino acid sequence of RG1 is approximately 89.7% similar to rat Mindin.

The present invention is also based in part on the expression profile of RG1, as demonstrated by its expression in prostate tissue libraries and over-expression in prostate tumor libraries. This tissue profile is seen in analysis of mRNA expression in tissue samples from normal and tumor tissues by PCR-based Taqman analysis. This method of analysis demonstrated that mRNA encoding RG1 is

highly expressed in prostate tissues as compared with other tissues.

Polynucleotides

In accordance with one aspect of the present invention, there are provided isolated
5 polynucleotides that encode the RG1 polypeptide having the deduced amino acid sequence of
Figure 2 (SEQ ID NO: 2).

Using the information provided herein, such as the polynucleotide sequence set out in Figure 1
(SEQ ID NO: 1), a polynucleotide of the present invention encoding a RG1 polypeptide may be obtained
using standard cloning and screening procedures, such as those for cloning cDNAs using mRNA from
10 cells of human tissue as starting material. Illustrative of the invention, the polynucleotide sequence in
Figure 1 (SEQ ID NO: 1) was found in cDNA clones obtained from human prostate tissues. *Rg1* was
identified as a gene expressed in the prostate by mining Incyte's LifeSeq database. The nucleotide
sequence was identified by an annotation search of the database, using the "Protein Function" tool
provided by Incyte for the purpose of searching the database. The nucleotide sequence was found in the
15 category of cell adhesion molecules in the annotated database and was described as a homologue of f-
spondin. Electronic Northern analysis of the distribution of *rg1* polynucleotide sequences in the set of
libraries in the database revealed that *rg1* was expressed at high levels in the prostate libraries and at
lower levels in a number of other tissue libraries, including those from normal and tumor tissues.

Following assembly of the set of *rg1* clones in the database into a contiguous polynucleotide
20 sequence, and editing of the contiguous sequence, a full-length coding sequence was identified in the
predicted assembled polynucleotide. This sequence coded for a protein with homology to rat mindin.

Incyte clones 1640796, 1712252, and 1880265 were obtained from Incyte for experimental work
and clone 3360733 was identified as containing the most 5' nucleotide sequence. This clone was fully
sequenced and contained the full coding sequence for the predicted RG1 protein. This sequence is
25 shown in Figure 1 (SEQ ID NO: 1).

Polynucleotides of the present invention may be in the form of RNA, such as mRNA, or in the
form of DNA, including, for instance, cDNA and genomic DNA obtained by cloning or produced by
chemical synthetic techniques or by a combination thereof, or by methods described herein. The DNA
may be double-stranded or single-stranded. Single-stranded DNA may be the coding strand, also
30 known as the sense strand, or it may be the non-coding strand, also referred to as the anti-sense
strand.

The sequence which encodes the polypeptide may be identical to the coding sequence of the
polynucleotide shown in Figure 1 (SEQ ID NO: 1). It also may be a polynucleotide with a different
sequence, which, as a result of the redundancy (degeneracy) of the genetic code, encodes the
35 polypeptide of Figure 2 (SEQ ID NO: 2).

Polynucleotides of the present invention which encode the polypeptide of Figure 2
(SEQ ID NO: 2) may include, but are not limited to, the coding sequence for the polypeptide itself; the

coding sequence of the polypeptide, together with additional, non-coding sequences, including for example, but not limited to, introns and non-coding 5' and 3' sequences, such as the transcribed, non-translated sequences that play a role in transcription, mRNA processing (for example, splicing and polyadenylation signals) or additional coding sequences which code for additional amino acids, such as those which provide additional functionalities. Thus, for instance, the polypeptide may be fused to a marker sequence, such as a peptide, which facilitates purification of the fused polypeptide. In certain preferred embodiments of this aspect of the invention, the marker sequence is a hexa-histidine peptide, such as the tag provided in a pTrcHisB vector (Invitrogen, Carlsbad, CA) among others, many of which are commercially available. As described in Gentz et al. (*Proc. Natl. Acad. Sci., USA* 86: 821-824, 1989), for instance, hexa-histidine provides for convenient purification of the fusion protein.

The polynucleotides may encode a polypeptide that is the polypeptide plus additional amino or carboxyl-terminal amino acids, or amino acids interior to the polypeptide (when the active form has more than one polypeptide chain, for instance). Such sequences may play a role in processing of a polypeptide from precursor to final form, may facilitate polypeptide trafficking, may prolong or shorten polypeptide half-life or may facilitate manipulation of a polypeptide for assay or production, among other things. As generally is the case *in situ*, the additional amino acids may be processed away from the polypeptide by proteolytic enzymes.

The present invention further relates to variants of the herein above described polynucleotides which encode for fragments, analogs and derivatives of the polypeptide having the deduced amino acid sequence of Figure 2 (SEQ ID NO: 2). A variant of the polynucleotide may be a naturally occurring variant such as a naturally occurring allelic variant, or it may be a variant that is not known to occur naturally. Such non-naturally occurring variants of the polynucleotide may be made by mutagenesis techniques, including those applied to polynucleotides, cells or organisms.

Among variants in this regard are variants that differ from the aforementioned polynucleotides by polynucleotide substitutions, deletions or additions. The substitutions, deletions or additions may involve one or more polynucleotides. The variants may be altered in coding or non-coding regions or both. Alterations in the coding regions may produce conservative or non-conservative amino acid substitutions, deletions or additions.

Among the particularly preferred embodiments of the invention in this regard are polynucleotides encoding polypeptides having the amino acid sequence of RG1 set out in Figure 2 (SEQ ID NO: 2); variants, analogs, derivatives and fragments thereof, and fragments of the variants, analogs and derivatives.

Further particularly preferred in this regard are polynucleotides encoding RG1 variants, analogs, derivatives and fragments, and variants, analogs and derivatives of the fragments, which have the amino acid sequence of the RG1 polypeptide of Figure 2 (SEQ ID NO: 2) in which several, a few, 5 to 10, 1 to 5, 1 to 3, 2, 1 or no amino acid residues are substituted, deleted or added, in any combination. Especially preferred among these are silent substitutions, additions and deletions, which do not alter the

properties and activities of the RG1 polypeptide. Also especially preferred in this regard are conservative substitutions. Most highly preferred are polynucleotides encoding polypeptides having the amino acid sequence of Figure 2 (SEQ ID NO: 2) without substitutions.

Further preferred embodiments of the invention are polynucleotides that are at least 70% identical to a polynucleotide encoding the RG1 polypeptide having the amino acid sequence set out in Figure 2 (SEQ ID NO: 2), and polynucleotides which are complementary to such polynucleotides. Alternatively, most highly preferred are polynucleotides that comprise a region that is at least 80% identical to a polynucleotide encoding the RG1 polypeptide and polynucleotides complementary thereto. In this regard, polynucleotides at least 90% identical to the same are particularly preferred, and among these particularly preferred polynucleotides, those with at least 95% are especially preferred. Furthermore, those with at least 97% are highly preferred among those with at least 95%, and among these, those with at least 98% and at least 99% are particularly highly preferred, with at least 99% being the more preferred.

Particularly preferred embodiments in this respect, moreover, are polynucleotides which encode polypeptides which retain substantially the same biological activity as the polypeptide encoded by the polynucleotide sequence of Figure 1 (SEQ ID NO: 1).

The present invention further relates to polynucleotides that hybridize to the herein above-described sequences. In this regard, the present invention especially relates to polynucleotides which hybridize under stringent conditions to the herein above-described polynucleotides.

As discussed additionally herein regarding polynucleotide assays of the invention, for instance, polynucleotides of the invention as discussed above, may be used as a hybridization probes for cDNA and genomic DNA to isolate full-length cDNAs and genomic clones encoding RG1 and to isolate cDNA and genomic clones of other genes that have a high sequence similarity to the *rg1* gene. Such probes generally will comprise at least 15 bases. Preferably, such probes will have at least 30 bases and may have at least 50 bases.

For example, the coding region of the *rg1* gene may be isolated by screening libraries using synthetic oligonucleotide probes that have been designed using the known DNA sequence. For example, a labeled oligonucleotide having a sequence complementary to that of a polynucleotide of the present invention can be used to screen a library of cDNA or genomic DNA to identify clones that hybridize to the probe.

In sum, a polynucleotide of the present invention may encode a polypeptide, a polypeptide plus a leader sequence (which may be referred to as a prepolypeptide).

It will be appreciated that the invention also relates to, among others, polynucleotides encoding the polypeptide fragments, polynucleotides that hybridize to polynucleotides encoding polypeptide fragments, particularly those that hybridize under stringent conditions, and polynucleotides, such as PCR primers, for amplifying polynucleotides that encode polypeptide fragments. In these regards, preferred polynucleotides are those that correspond to preferred polypeptide fragments, as discussed

below.

Polypeptides

The present invention further relates to a RG1 polypeptide that has the deduced amino acid
5 sequence of Figure 2 (SEQ ID NO: 2).

The invention also relates to fragments, analogs and derivatives of these polypeptides. The terms fragment, derivative and analog when referring to the polypeptide of Figure 2 (SEQ ID NO: 2) means a polypeptide which retains essentially the same biological activity as such a polypeptide.

The polypeptide of the present invention may be a recombinant polypeptide, a natural
10 polypeptide or a synthetic polypeptide. In certain preferred embodiments, it is a recombinant polypeptide.

The fragment, derivative or analog of the polypeptide of Figure 2 (SEQ ID NO: 2) may be
(i) one in which one or more of the amino acid residues are substituted with a conserved or non-
conserved amino acid residue (preferably a conserved amino acid residue) and such substituted amino
15 acid residue may or may not be one encoded by the genetic code, or (ii) one in which one or more of the amino acid residues includes a substituent group, or (iii) one in which the polypeptide is fused with another compound, such as a compound to increase the half-life of the polypeptide (for example, polyethylene glycol) or (iv) one in which the additional amino acids are fused to the polypeptide, such as a leader or secretory sequence or a sequence which is employed for purification of the polypeptide.
20 Such fragments, derivatives and analogs are deemed to be within the scope of those skilled in the art from the teachings herein.

Among the particularly preferred embodiments of the invention in this regard are polypeptides having the amino acid sequence of RG1 set out in Figure 2 (SEQ ID NO: 2), variants, analogs, derivatives and fragments thereof, and variants, analogs and derivatives of the fragments.

25 Among preferred variants are those that vary from a reference by conservative amino acid substitutions. Such substitutions are those that substitute a given amino acid in a polypeptide by another amino acid of like characteristics. Typically seen as conservative substitutions are the replacements, one for another, among the aliphatic amino acids Ala, Val, Leu and Ile, interchange of the hydroxyl residues Ser and Thr, exchange of the acidic residues Asp and Glu, substitution between the
30 amide residues Asn and Gln, exchange of the basic residues Lys and Arg and replacements among the aromatic residues Phe and Tyr.

Further particularly preferred in this regard are variants, analogs, derivatives and fragments, and variants, analogs and derivatives of the fragments, having the amino acid sequence of the RG1 polypeptide of Figure 2 (SEQ ID NO: 2) in which several, a few, 5 to 10, 1 to 5, 1 to 3, 2, 1 or no
35 amino acid residues are substituted, deleted or added, in any combination. Especially preferred among these are silent substitutions, additions and deletions, which do not alter the properties and activities of the RG1 polypeptide. Also especially preferred in this regard are conservative substitutions. Most

highly preferred are polypeptides having the amino acid sequence of Figure 2 (SEQ ID NO: 2) without substitutions.

The polypeptides and polynucleotides of the present invention are preferably provided in an isolated form, and preferably are purified to homogeneity.

5 The polypeptides of the present invention also include the polypeptide of Figure 2 (SEQ ID NO: 2) as well as polypeptides which have at least 70% similarity (preferably at least 70% identity) to the polypeptide of Figure 2 (SEQ ID NO: 2) and more preferably at least 90% similarity (more preferably at least 90% identity) to the polypeptide of Figure 2 (SEQ ID NO: 2) and still more preferably at least 95% similarity (still more preferably at least 95% identity) to the polypeptide of Figure 2 (SEQ ID
10 NO: 2) and also include portions of such polypeptides with such portion of the polypeptide generally containing at least 30 amino acids and more preferably at least 50 amino acids.

As known in the art "similarity" between two polypeptides is determined by comparing the amino acid sequence and its conserved amino acid substitutes of one polypeptide to the sequence of a second polypeptide.

15 Fragments or portions of the polypeptides of the present invention may be employed for producing the corresponding full-length polypeptides by peptide synthesis; therefore, the fragments may be employed as intermediates for producing the full-length polypeptides.

Polypeptide Fragments

20 Also among preferred embodiments of this aspect of the present invention are polypeptides comprising fragments of RG1, most particularly fragments of the RG1 of Figure 2 (SEQ ID NO: 2), and fragments of variants and derivatives of the RG1 of Figure 2 (SEQ ID NO: 2).

In this regard a fragment is a polypeptide having an amino acid sequence that entirely is the same as part but not all of the amino acid sequence of the aforementioned RG1 polypeptides and
25 variants or derivatives thereof.

Such fragments may be "free-standing," i.e., not part of or fused to other amino acids or polypeptides, or they may be comprised within a larger polypeptide of which they form a part or region. When comprised within a larger polypeptide, the presently discussed fragments most preferably form a single continuous region. However, several fragments may be comprised within a single larger
30 polypeptide. For instance, certain preferred embodiments relate to a fragment of an RG1 polypeptide of the present invention comprised within a precursor polypeptide designed for expression in a host and having heterologous pre- and propolypeptide regions fused to the amino terminus of the RG1 fragment and an additional region fused to the carboxyl terminus of the fragment. Therefore, fragments in one aspect of the meaning intended herein, refers to the portion or portions of a fusion polypeptide or fusion
35 protein derived from RG1.

As representative examples of polypeptide fragments of the invention, there may be mentioned those which have from about 25 to about 331 amino acids.

In this context "about" includes the particularly recited range and ranges larger or smaller by several, a few, 5, 4, 3, 2 or 1 amino acid at either extreme or at both extremes. For instance, about 331 amino acids in this context means a polypeptide fragment of 25 plus or minus several, a few, 5, 4, 3, 2 or 1 amino acids to 331 plus or minus several a few, 5, 4, 3, 2 or 1 amino acid residues, i.e., ranges as broad as 25 minus several amino acids to 331 plus several amino acids to as narrow as 25 plus several amino acids to 331 minus several amino acids.

Highly preferred in this regard are the recited ranges plus or minus as many as 5 amino acids at either or at both extremes. Particularly highly preferred are the recited ranges plus or minus as many as 3 amino acids at either or at both the recited extremes. Especially particularly highly preferred are ranges plus or minus 1 amino acid at either or at both extremes or the recited ranges with no additions or deletions. Most highly preferred of all in this regard are fragments from about 25 to about 331 amino acids.

Among especially preferred fragments of the invention are truncation mutants of RG1. Truncation mutants of RG1 include variants or derivatives of the sequence of Figure 2 (SEQ ID NO: 2), except for deletion of a continuous series of residues (that is, a continuous region, part or portion) that includes the amino terminus of the sequence shown in Figure 2 (SEQ ID NO: 2), or a continuous series of residues that includes the carboxyl terminus or, as in double truncation mutants, deletion of two continuous series of residues, one including the amino terminus and one including the carboxyl terminus. Fragments having the size ranges set out above also are preferred embodiments of truncation fragments, which are especially preferred among fragments generally.

Especially preferred in this aspect of the invention are fragments characterized by biological and/or immunological attributes of RG1. Such fragments include those containing the predicted structural domains of RG1, which encompass at least amino acid 31 to 103, 138 to 221 and 278 to 330 or those fragments used to generate antibodies, such as those described in Example 4.

Certain preferred regions in these regards are set out in Figure 2 (SEQ ID NO: 2), and include, but are not limited to, regions of the aforementioned types identified by analysis of the amino acid sequence set out in Figure 2 (SEQ ID NO: 2).

Among highly preferred fragments in this regard are those that comprise regions of RG1 that combine several structural features, such as the features set out above. In this regard, the two spondin and one thrombospondin domains, encompassing about amino acids 31 to 103, 138 to 221, and 278 to 330, respectively, which are characteristic of the Mindin/spondin superfamily of extracellular matrix proteins, are especially preferred regions. Such regions may be comprised within a larger polypeptide or may be by themselves a preferred fragment of the present invention, as discussed above. It will be appreciated that the term "about" as used in this paragraph has the meaning set out above regarding fragments in general.

Further preferred regions are those that mediate activities of RG1. Most highly preferred in this regard are fragments that have a chemical, biological or other activity of RG1, including those with a

similar activity or an improved activity, or with a decreased undesirable activity. Highly preferred in this regard are fragments that contain regions that are homologs in sequence, or in position, or in both sequence and position to active regions of related polypeptides, such as the other proteins of the Mindin family, which includes RG1.

5

Vectors, host cells, and expression systems

The present invention also relates to vectors which include polynucleotides of the present invention, host cells which are genetically engineered with vectors of the invention and the production of polypeptides of the invention by recombinant techniques. Such techniques are described in

10 Sambrook et al., *Molecular Cloning, A Laboratory Manual*, Cold Spring Harbor Press, Plainview, N.Y., 1989 and Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, John Wiley & Sons, New York, N.Y., 1989.

Host cells can be genetically engineered to incorporate polynucleotides and express polypeptides of the present invention. For instance, polynucleotides may be introduced into host cells
15 using well known techniques of infection, transduction, transfection, transvection and transformation. The polynucleotides may be introduced alone or with other polynucleotides. Such other polynucleotides may be introduced independently, co-introduced or introduced joined to the polynucleotides of the invention.

Thus, for instance, polynucleotides of the invention may be transfected into host cells with
20 another, separate, polynucleotide encoding a selectable marker, using standard techniques for co-transfection and selection in, for instance, mammalian cells. In this case, the polynucleotides generally will be stably incorporated into the host cell genome.

Alternatively, the polynucleotides may be joined to a vector containing a selectable marker for propagation in a host. The vector construct may be introduced into host cells by the aforementioned
25 techniques. Generally, a plasmid vector is introduced as DNA in a precipitate, such as a calcium phosphate precipitate, or in a complex with a charged lipid. Electroporation also may be used to introduce polynucleotides into a host. If the vector is a virus, it may be packaged *in vitro* or introduced into a packaging cell and the packaged virus may be transduced into cells. A wide variety of techniques suitable for making polynucleotides and for introducing polynucleotides into cells in accordance with this
30 aspect of the invention are well known and routine to those of skill in the art. Such techniques are reviewed at length in Sambrook et al. cited above, which is illustrative of the many laboratory manuals that detail these techniques. In accordance with this aspect of the invention, the vector may be, for example, a plasmid vector, a single or double-stranded phage vector, a single or double-stranded RNA or DNA viral vector. Such vectors may be introduced into cells as polynucleotides, preferably DNA, by
35 well known techniques for introducing DNA and RNA into cells. The vectors, in the case of phage and viral vectors, also may be and preferably are introduced into cells as packaged or encapsidated virus by well known techniques for infection and transduction. Viral vectors may be replication competent or

replication defective. In the latter case viral propagation generally will occur only in complementing host cells.

Preferred among vectors, in certain respects, are those for expression of polynucleotides and polypeptides of the present invention. Generally, such vectors comprise cis-acting control regions effective for expression in a host operatively linked to the polynucleotide to be expressed. Appropriate trans-acting factors either are supplied by the host, supplied by a complementing vector or supplied by the vector itself upon introduction into the host.

In certain preferred embodiments in this regard, the vectors provide for specific expression. Such specific expression may be inducible expression or expression only in certain types of cells or both inducible and cell-specific. Particularly preferred among inducible vectors are vectors that can be induced for expression by environmental factors that are easy to manipulate, such as temperature and nutrient additives. A variety of vectors suitable to this aspect of the invention, including constitutive and inducible expression vectors for use in prokaryotic and eukaryotic hosts, are well known and employed routinely by those of skill in the art.

The engineered host cells can be cultured in conventional nutrient media, which may be modified as appropriate for, *inter alia*, activating promoters, selecting transformants or amplifying genes. Culture conditions, such as temperature, pH and the like, previously used with the host cell selected for expression generally will be suitable for expression of polypeptides of the present invention as will be apparent to those of skill in the art.

A great variety of expression vectors can be used to express a polypeptide of the invention. Such vectors include chromosomal, episomal and virus-derived vectors e.g., vectors derived from bacterial plasmids, from bacteriophage, from yeast episomes, from yeast chromosomal elements, from viruses such as baculoviruses, papova viruses, such as SV40, vaccinia viruses, adenoviruses, fowl pox viruses, pseudorabies viruses, retroviruses, and alphaviruses such as Sindbis virus, and vectors derived from combinations thereof, such as those derived from plasmid and bacteriophage genetic elements such as cosmids and phagemids, all may be used for expression in accordance with this aspect of the present invention. Generally, any vector suitable to maintain, propagate or express polynucleotides to express a polypeptide in a host may be used for expression in this regard.

The appropriate DNA sequence may be inserted into the vector by any of a variety of well-known and routine techniques. In general, a DNA sequence for expression is joined to an expression vector by cleaving the DNA sequence and the expression vector with one or more restriction endonucleases and then joining the restriction fragments together using T4 DNA ligase. Procedures for restriction and ligation that can be used to this end are well known and routine to those of skill. Suitable procedures in this regard, and for constructing expression vectors using alternative techniques, which also are well known and routine to those of skill, are set forth in great detail in Sambrook et al. cited elsewhere herein.

The DNA sequence in the expression vector is operatively linked to appropriate expression

control sequence(s), including, for instance, a promoter to direct mRNA transcription. Representatives of such promoters include the phage lambda PL promoter, the *E. coli* lac, trp, tac, and trc promoters, the SV40 early and late promoters and promoters of retroviral LTRs, to name just a few of the well-known promoters. It will be understood that numerous promoters not mentioned are suitable for use in this aspect of the invention, are well known and may readily be employed by those of skill in the manner illustrated by the discussion and the examples herein.

In general, expression constructs will contain sites for transcription initiation and termination, and, in the transcribed region, a ribosome binding site for translation. The coding portion of the transcripts expressed by the constructs will include a translation initiating AUG at the beginning and a termination codon appropriately positioned at the end of the polypeptide to be translated.

In addition, the constructs may contain control regions that regulate as well as engender expression. Generally, in accordance with many commonly practiced procedures, such regions will operate by controlling transcription, such as repressor binding sites and enhancers, among others.

Vectors for propagation and expression generally will include selectable markers. Such markers also may be suitable for amplification or the vectors may contain additional markers for this purpose. In this regard, the expression vectors preferably contain one or more selectable marker genes to provide a phenotypic trait for selection of transformed host cells. Preferred markers include dihydrofolate reductase, neomycin, puromycin, or hygromycin resistance for eukaryotic cell culture, and tetracycline, theomycin, kanamycin or ampicillin resistance genes for culturing *E. coli* and other bacteria.

The vector containing the appropriate DNA sequence as described elsewhere herein, as well as an appropriate promoter, and other appropriate control sequences, may be introduced into an appropriate host using a variety of well known techniques suitable to expression therein of a desired polypeptide. Representative examples of appropriate hosts include bacterial cells, such as *E. coli*, *Streptomyces* and *Salmonella typhimurium* cells; fungal cells, such as yeast cells; insect cells such as *Drosophila* S2 and *Spodoptera* Sf9 cells; animal cells such as CHO, COS and Bowes melanoma cells; and plant cells, preferably insect cells BTI-TN-5B1-4. Hosts for a great variety of expression constructs are well known, and those of skill will be enabled by the present disclosure readily to select a host for expressing a polypeptides in accordance with this aspect of the present invention.

Various mammalian cell culture systems can be employed for expression, as well. Examples of mammalian expression systems include the COS-7 lines of monkey kidney fibroblast (Gluzman et al., *Cell* 23: 175, 1991). Other cell lines capable of expressing a compatible vector include for example, the C127, 3T3, CHO, HeLa, human kidney 293 and BHK cell lines. In mammalian host cells, a number of viral-based expression systems may be utilized. In cases where an adenovirus is used as an expression vector, the polynucleotide sequence coding for RG1 may be ligated into an adenovirus transcription/translation complex consisting of the late promoter and tripartite leader sequence. Insertion in a nonessential E1 or E3 region of the viral genome will result in a viable virus capable of expressing RG1 in infected host cells (Logan and Shenk, *Proc. Natl. Acad. Sci. USA* 81:3655-59,

1984). In addition, transcription enhancers, such as the Rous sarcoma virus (RSV) enhancer, may be used to increase expression in mammalian host cells.

More particularly, the present invention also includes recombinant constructs, such as expression constructs, comprising one or more of the sequences described above. The constructs
5 comprise a vector, such as a plasmid or viral vector, into which such a sequence of the invention has been inserted. The sequence may be inserted in a forward or reverse orientation. In certain preferred embodiments in this regard, the construct further comprises regulatory sequences, including, for example, a promoter, operably linked to the sequence. Large numbers of suitable vectors and promoters are known to those of skill in the art, and there are many commercially available vectors
10 suitable for use in the present invention.

The following vectors, which are commercially available, are provided by way of example. Among vectors preferred for use in bacteria are pQE70, pQE60 and pQE-9, available from Qiagen USA (Valencia, CA); pBS vectors, Phagescript® vectors, Bluescript® vectors, pNH8A, pNH16a, pNH18A, pNH46A, available from Stratagene (LaJolla, CA); and ptrc99a, pK223-3, pKK233-3, pDR540, pRIT5
15 available from Pharmacia Biotech (Piscataway, N.J.). Most preferred is the pTrcHisB vector, available from Invitrogen. Among preferred eukaryotic vectors are pWLNEO, pSV2CAT, pOG44, PXTI and pSG available from Stratagene; and PSVK3, pBPV, pMSG and pSVL available from Pharmacia Biotech. Most preferred is the pCIneo vector available from Promega. These vectors are listed solely by way of illustration of the many commercially available and well known vectors that are available to those of skill
20 in the art for use in accordance with this aspect of the present invention. It will be appreciated that any other plasmid or vector suitable for, for example, introduction, maintenance, propagation or expression of a polynucleotide or polypeptide of the invention in a host may be used in this aspect of the invention.

Promoter regions can be selected from any desired gene using vectors that contain a reporter transcription unit lacking a promoter region, such as a chloramphenicol acetyl transferase ("cat")
25 transcription unit, downstream of restriction site or sites for introducing a candidate promoter fragment; i.e., a fragment that may contain a promoter. As is well known, introduction into the vector of a promoter-containing fragment at the restriction site upstream of the cat gene engenders production of CAT activity, which can be detected by standard CAT assays. Vectors suitable to this end are well known and readily available. Two such vectors are pKK232-B and pCM7. Thus, promoters for
30 expression of polynucleotides of the present invention include not only well known and readily available promoters, but also promoters that readily may be obtained by the foregoing technique, using a reporter gene.

Among known bacterial promoters suitable for expression of polynucleotides and polypeptides in accordance with the present invention are the *E. coli* lacI and lacZ promoters, the T3 and T7
35 promoters, the T5 tac promoter, the lambda PR, PL promoters, the trp promoter, and the trc hybrid promoter, which is derived from the trp and lac promoters. Among known eukaryotic promoters suitable in this regard are the CMV immediate early promoter, the HSV thymidine kinase promoter, the early and

late SV40 promoters, the promoters of retroviral LTRs, such as those of the Rous sarcoma virus ("RSV") and metallothionein promoters, such as the mouse metallothionein-I promoter.

Selection of appropriate vectors and promoters for expression in a host cell is a well known procedure and the requisite techniques for expression vector construction, introduction of the vector into the host and expression in the host are routine skills in the art.

Generally, recombinant expression vectors will include origins of replication, a promoter derived from a highly-expressed gene to direct transcription of a downstream structural sequence, and a selectable marker to permit isolation of vector containing cells after exposure to the vector.

The present invention also relates to host cells containing the above-described constructs discussed above. The host cell can be a higher eukaryotic cell, such as a mammalian cell, or a lower eukaryotic cell, such as a yeast cell, or the host cell can be a prokaryotic cell, such as a bacterial cell. Constructs in host cells can be used in a conventional manner to produce the gene product encoded by the recombinant sequence.

Polypeptides can be expressed in mammalian cells, yeast, bacteria, or other cells under the control of appropriate promoters. Cell-free translation systems can also be employed to produce such proteins using RNAs derived from the DNA constructs of the present invention. Appropriate cloning and expression vectors for use with prokaryotic and eukaryotic hosts are described by Sambrook et al., cited elsewhere herein.

Transcription of the DNA encoding the polypeptides of the present invention by higher eukaryotes may be increased by inserting an enhancer sequence into the vector. Enhancers are cis-acting elements of DNA, usually about from 10 to 300 bp that act to increase transcriptional activity of a promoter in a given host cell-type. Examples of enhancers include the SV40 enhancer, which is located on the late side of the replication origin at bp 100 to 270, the cytomegalovirus early promoter enhancer, the polyoma enhancer on the late side of the replication origin, and adenovirus enhancers.

Polynucleotides of the invention, encoding the heterologous structural sequence of a polypeptide of the invention generally will be inserted into the vector using standard techniques so that it is operably linked to the promoter for expression. The polynucleotide will be positioned so that the transcription start site is located appropriately 5' to a ribosome binding site. The ribosome binding site will be 5' to the AUG that initiates translation of the polypeptide to be expressed. Generally, there will be no other open reading frames that begin with an initiation codon, usually AUG, and lie between the ribosome binding site and the initiating AUG. Also, generally, there will be a translation stop codon at the end of the polypeptide and there will be a polyadenylation signal and a transcription termination signal appropriately disposed at the 3' end of the transcribed region.

For secretion of the translated protein into the lumen of the endoplasmic reticulum, into the periplasmic space or into the extracellular environment, appropriate secretion signals may be incorporated into the expressed polypeptide. The signals may be endogenous to the polypeptide or they may be heterologous signals. The polypeptide may be expressed in a modified form, such as a

fusion protein, and may include not only secretion signals but also additional heterologous functional regions. Thus for instance, a region of additional amino acids, particularly charged amino acids, may be added to the N-terminus of the polypeptide to improve stability and persistence in the host cell, during purification or during subsequent handling and storage. Also, special regions also may be added to the polypeptide to facilitate purification. Such regions may be removed prior to final preparation of the polypeptide. The addition of peptide moieties to polypeptides to engender secretion or excretion, to improve stability and to facilitate purification, among others, are familiar and routine techniques in the art. For example, when large quantities of RG1 are needed for the induction of antibodies, vectors which direct high level expression of fusion proteins that are readily purified may be desirable. Such vectors include, but are not limited to, the multifunctional *E. coli* cloning and expression vectors such as Bluescript® (Stratagene), in which the *rg1* coding sequence may be ligated into the vector in frame with sequence for the amino-terminal Met and the subsequent 7 residues of β -galactosidase so that a hybrid protein is produced; pIN vectors (Van Heede and Shuster, *J. Biol. Chem.* 264:5503-5509, 1989) and the like. PTrcHis vectors (Invitrogen, Carlsbad, CA) may be used to express foreign polypeptides as fusion proteins containing a polyhistidine (6xHis) tag for rapid purification. Proteins made in such systems are designed to include cleavage sites, such as an enterokinase cleavage site, so that the cloned polypeptide of interest can be released from the fusion peptide moiety at will.

Following transformation of a suitable host strain and growth of the host strain to an appropriate cell density, inducible promoters, if present, can be induced by appropriate means (e.g., temperature shift or exposure to chemical inducer) and cells cultured for an additional period.

Cells typically then are harvested by centrifugation, disrupted by physical or chemical means, and the resulting crude extract retained for further purification.

Microbial cells employed in expression of proteins can be disrupted by any convenient method, including freeze-thaw cycling, sonication, mechanical disruption, or use of cell lysing agents, such methods are well known to those skilled in the art.

The RG1 polypeptide can be recovered and purified from recombinant cell cultures by well-known methods including ammonium sulfate or ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography, hydroxylapatite chromatography and lectin chromatography. Most preferably, high performance liquid chromatography ("HPLC") is employed for purification. Well known techniques for refolding protein may be employed to regenerate active conformation when the polypeptide is denatured during isolation and or purification. Various other methods of protein purification well known in the art include those described in Deutscher, M., *Methods in Enzymology*, Vol 182, Academic Press, San Diego, 1982; and Scopes, R., *Protein Purification: Principles and Practice* Springer-Verlag, New York, 1982.

Alternatively, the polypeptides of the present invention can be produced by direct peptide synthesis using solid-phase techniques (Stewart et al., *Solid-Phase Peptide Synthesis*, W. H. Freeman

Co., San Francisco, 1969; Merrifield, J., *J. Am. Chem. Soc.* 85:2149-2154, 1963). *In vitro* protein synthesis may be performed using manual techniques or by automation. Automated synthesis may be achieved, for example, using Applied Biosystems 431A Peptide Synthesizer (Perkin Elmer, Foster City, Calif) in accordance with the instructions provided by the manufacturer. Various fragments of RG1 may be chemically synthesized separately and combined using chemical methods to produce the full length molecule.

Polypeptides of the present invention include naturally purified products, products of chemical synthetic procedures, and products produced by recombinant techniques from a prokaryotic or eukaryotic host, including, for example, bacterial, yeast, higher plant, insect and mammalian cells. Depending upon the host employed in a recombinant production procedure, the polypeptides of the present invention may be glycosylated or may be non-glycosylated. In addition, polypeptides of the invention may also include an initial modified methionine residue, in some cases as a result of host-mediated processes.

Uses of RG1 polypeptides and the polynucleotides which encode them

Rg1 polynucleotides and RG1 polypeptides may be used in accordance with the present invention for a variety of applications, particularly those that make use of the chemical and biological properties of RG1. Additional applications relate to diagnosis and to treatment of diseases of cell proliferation, such as prostate cancer. These aspects of the invention are illustrated further by the following discussion and are described further within the body of the specification.

The rationale for the use of the polynucleotide and polypeptide sequences of the present invention is based in part on the chemical and structural homology between the RG1 disclosed herein and other extracellular matrix molecules and on the preferential expression of RG1 in prostate tissues as compared with other tissues. RG1 may be used in the diagnosis and treatment of conditions, disorders or diseases associated with inappropriate growth of prostate tissue. These would include, but are not limited to, cancer and metastatic tumor growth, e.g. prostate cancer and metastasis.

Rg1 polynucleotide sequences can be used as DNA probes, and as targets for antisense and ribozyme therapy, or as templates for the production of antisense polynucleotides.

RG1 polypeptides can be used to generate antibodies to RG1 that may be useful in detecting the levels of RG1 polypeptide in cells and tissues and in targeting drugs to primary and metastatic tumors.

RG1 polypeptides may be used to stimulate an immune response to RG1 containing cells.

Polynucleotides encoding RG1 may be useful in diagnostic assays for detecting the levels of polynucleotides encoding RG1 in cells and tissues.

In conditions associated with expression of RG1, such as prostate cancer, it may be advantageous to suppress expression or activity of RG1. RG1 expression could be suppressed by administration of antisense oligonucleotides or ribozymes. Alternatively, antibodies specifically

recognizing areas of the RG1 may be administered to treat diseases or conditions associated with RG1 expression.

Polynucleotide assays

5 This invention is also related to the use of the *rg1*-related polynucleotides to detect complementary polynucleotides such as, for example, as a diagnostic reagent. Detection of *rg1* polynucleotides associated with a disease state will provide a tool for the development of *in vitro* and *in vivo* diagnostics that can add or define a diagnosis of a disease or susceptibility to a disease that results from tissue specific expression of RG1.

10 Individuals carrying mutations in the gene encoding RG1 may be detected at the DNA level by a variety of techniques. Polynucleotide samples for diagnosis may be obtained from a patient's cells, such as from blood, urine, saliva, tissue biopsy and autopsy material. The genomic DNA may be used directly for detection or may be amplified enzymatically by using PCR prior to analysis (Saiki et al., *Nature*, 324: 163-166, 1986). RNA or cDNA may also be used in the same ways. As an example, PCR
15 primers complementary to the polynucleotide sequence encoding RG1 can be used to identify and analyze *rg1* expression and mutations. For example, deletions and insertions can be detected by a change in size of the amplified product in comparison to the normal genotype. Point mutations can be identified by hybridizing amplified DNA to radiolabeled *rg1* RNA or alternatively, radiolabeled *rg1* antisense DNA sequences. Perfectly matched sequences can be distinguished from mismatched
20 duplexes by RNase A digestion or by differences in melting temperatures.

Sequence differences between a reference gene and genes having mutations also may be revealed by direct DNA sequencing. In addition, cloned DNA segments may be employed as probes to detect specific DNA segments. The sensitivity of such methods can be greatly enhanced by appropriate use of PCR or another amplification method. For example, a sequencing primer is used with double-
25 stranded PCR product or a single-stranded template molecule generated by a modified PCR. The sequence determination is performed by conventional procedures with radiolabeled polynucleotide or by automatic sequencing procedures with fluorescent tags.

Genetic testing based on DNA sequence differences may be achieved by detection of alteration in electrophoretic mobility of DNA fragments in gels, with or without denaturing agents. Small sequence
30 deletions and insertions can be visualized by high resolution gel electrophoresis. DNA fragments of different sequences may be distinguished on denaturing formamide gradient gels in which the mobilities of different DNA fragments are retarded in the gel at different positions according to their specific melting or partial melting temperatures (see, e.g., Myers et al., *Science*, 230: 1242, 1985).

Sequence changes at specific locations also may be revealed by nuclease protection assays,
35 such as RNase and S1 protection or the chemical cleavage method (e.g., Catton et al., *Proc. Natl. Acad. Sci., USA*, 85:4397-4401, 1985).

Thus, the detection of a specific DNA sequence may be achieved by methods such as

hybridization, RNase protection, chemical cleavage, direct DNA sequencing or the use of restriction enzymes, (e.g., restriction fragment length polymorphisms ("RFLP") and Southern blotting of genomic DNA).

In addition to more conventional gel-electrophoresis and DNA sequencing, mutations also can be detected by *in situ* analysis.

Polypeptide assays

The present invention also relates to diagnostic assays such as quantitative and diagnostic assays for detecting levels of RG1 polypeptide in cells and tissues and body fluids, including determination of normal and abnormal levels. Thus, for instance, a diagnostic assay in accordance with the invention for detecting over-expression of RG1 polypeptide compared to normal control tissue samples may be used to detect the presence of neoplasia, for example, prostate cancer. Such diagnostic tests may be used to detect metastatic tumor growth, as well. Assay techniques that can be used to determine levels of a polypeptide, such as a RG1 polypeptide of the present invention, in a sample derived from a host are well-known to those of skill in the art. Such assay methods include radioimmunoassays (RIA), competitive-binding assays, western Blot analysis and enzyme-linked immunoabsorbant assays (ELISA), fluorescent activated cell sorting (FACS), and surface plasmon resonance. Among these ELISAs frequently are preferred. An ELISA assay initially comprises preparing an antibody specific to RG1, preferably a monoclonal antibody. In addition a reporter antibody generally is prepared which binds to the monoclonal antibody or is directly conjugated to the antibody. The reporter antibody is attached to a detectable reagent such as a radioactive, fluorescent or enzymatic reagent, in this example horseradish peroxidase enzyme.

To carry out an ELISA a sample is removed from a host and incubated on a solid support, e.g. a polystyrene dish, that binds the polypeptides in the sample. Any free polypeptide binding sites on the dish are then covered by incubating with a non-specific protein such as bovine serum albumin. Next, the monoclonal antibody is incubated in the dish during which time the monoclonal antibodies attach to any RG1 polypeptides attached to a solid support. Unbound monoclonal antibody is separated from bound antibody by washing with buffer. The reporter antibody linked to horseradish peroxidase is placed in the dish resulting in binding of the reporter antibody to any monoclonal antibody bound to RG1. Unattached reporter antibody is then washed out. Reagents for peroxidase activity, including a colorimetric substrate are then added to the dish. Immobilized peroxidase, linked to RG1 through the primary and secondary antibodies, produces a colored reaction product. The amount of color developed in a given time period indicates the amount of RG1 polypeptide present in the sample. Quantitative results typically are obtained by reference to a standard curve.

A competition assay may be employed wherein antibodies specific to RG1 are attached to a solid support and labeled RG1 and a sample derived from the host are passed over the solid support and the amount of label detected attached to the solid support can be correlated to a quantity of RG1 in

the sample.

These and other assays are described, among other places, in Hampton et al. (*Serological Methods, a Laboratory Manual*, APS Press, St Paul, Minn, 1990) and Maddox et al. (*J. Exp. Med.* 158:12111, 1983).

5

Antibodies

The present invention further relates to antibodies, antigen-binding antibody fragments thereof, and variants of the antibodies and fragments, that specifically bind to an RG1 polypeptide, particularly to the RG1 polypeptide having the amino acid sequence of SEQ ID NO: 2. These antibodies can be, for example, polyclonal or monoclonal antibodies. More preferred are monoclonal antibodies. Still more preferred are chimeric or humanized antibodies, and still more preferred are human antibodies.

The antibodies, antigen-binding antibody fragments, and variants of the antibodies and fragments, contemplated in the present invention bind to an epitope of the RG1 polypeptide with a dissociation constant (K_D) less than or equal to $1\mu\text{M}$. More preferred are antibodies which bind with a K_D less than or equal to 100nM . Most preferred are antibodies which bind with a K_D less than or equal to 10nM . Also contemplated are antibodies which recognize and bind to the same epitope as the epitope bound by the antibodies described below, and which can be determined through competitive binding studies, using techniques well-known to those skilled in the art.

The antibodies, antigen-binding antibody fragments, and variants of the antibodies and fragments of the invention are comprised of a light chain variable region and a heavy chain variable region. Among the preferred embodiments of the invention in this regard are antibodies, antigen-binding antibody fragments thereof, or variants thereof, comprising a light chain variable region having at least 80%, more preferably at least 90%, still more preferably at least 95%, and still more preferably 99% sequence identity to the amino acid sequences of SEQ ID NO: 26 or SEQ ID NO: 29. Also preferred embodiments are antibodies, antigen-binding antibody fragments thereof, or variants thereof, comprising a heavy chain variable region having at least 80%, more preferably at least 90%, still more preferably at least 95%, and still more preferably 99% sequence identity to the amino acid sequences of SEQ ID NO: 27, SEQ ID NO: 28, SEQ ID NO: 30 or SEQ ID NO: 31 (see Figures 9 and 10).

Particularly preferred embodiments of the invention are antibodies or antigen-binding antibody fragments thereof, or variants thereof, comprising a light chain variable region having the amino acid sequence SEQ ID NO: 26 or SEQ ID NO: 29, which are encoded by the nucleotide sequences SEQ ID NOS: 20 and 23, respectively.

Also particularly preferred are antibodies, or antigen-binding antibody fragments thereof, or variants thereof, comprising a heavy chain variable region having an amino acid sequence chosen from SEQ ID NOS: 27, 28, 30 or 31, which are encoded by the nucleotide sequences SEQ ID NOS: 21, 22, 24 and 25, respectively.

More particularly preferred in this regard are an antibody, or antigen-binding antibody fragment thereof, or a variant thereof, comprising a light chain variable region having the amino acid sequence SEQ ID NO: 26 and further comprising a heavy chain variable region having the amino acid sequence SEQ ID NO: 27 or SEQ ID NO: 28 and a second antibody comprising a light chain variable region
5 having the amino acid sequence SEQ ID NO: 29 and further comprising a heavy chain variable region having the amino acid sequence SEQ ID NO: 30 or SEQ ID NO: 31.

Most preferred are the human antibodies, or antigen-binding antibody fragments thereof, or variants thereof, as follows: (a) an antibody comprised of a light chain variable region having the amino acid sequence SEQ ID NO: 26 and a heavy chain variable region having the amino acid sequence
10 SEQ ID NO: 27, (b) an antibody comprised of a light chain variable region having the amino acid sequence SEQ ID NO: 26 and a heavy chain variable region having the amino acid sequence SEQ ID NO: 28, (c) an antibody comprised of a light chain variable region having the amino acid sequence SEQ ID NO: 29 and a heavy chain variable region having the amino acid sequence SEQ ID NO: 30, or (d) an antibody comprised of a light chain variable region having the amino acid
15 sequence SEQ ID NO: 29 and a heavy chain variable region having the amino acid sequence SEQ ID NO: 31.

Antibody Production

RG1 polypeptides, fragments or derivatives, or cells expressing them can be used as an
20 immunogen to produce antibodies thereto (Harlow, *Antibodies*, Cold Spring Harbor Press, NY (1989)). Various procedures known in the art may be used for the production of such antibodies and fragments (C. A. K. Borrebaeck, editor (1995) *Antibody Engineering (Breakthroughs in Molecular Biology)*, Oxford University Press; R. Kontermann & S. Duebel, editors (2001) *Antibody Engineering (Springer Laboratory Manual)*, Springer Verlag).

25 Antibodies generated against RG1 can be obtained by direct injection of the polypeptides into an animal or by administering the polypeptides to an animal, preferably a nonhuman. The antibody so obtained will then bind the polypeptides itself. In this manner, even a sequence encoding only a fragment of the polypeptides can be used to generate antibodies binding the whole native polypeptides. Such antibodies can then be used to isolate the polypeptide from tissue expressing that polypeptide.
30 Alternate methods that do not require the use of purified RG1 protein or RG1 peptides to generate antibodies to RG1, include 'DNA immunization' in which an expression vector or virus is created using DNA coding for RG1 and is used to transfect or infect host tissue cells to express RG1 in the animal used to generate antibodies, or cell based immunization in which cell lines expressing RG1 created *in vitro* are used in the immunization procedure.

35 Monoclonal antibodies can be prepared using any technique which provides antibodies produced by continuous cell line cultures. Examples include the hybridoma technique (Kohler and Milstein, *Nature* 256: 495-497, 1975), the human B-cell hybridoma technique (Kozbor et al.,

Immunology Today 4: 72, 1983) and the EBV-hybridoma technique to produce human monoclonal antibodies (Cole et al., in *Monoclonal Antibodies and Cancer*, Alan R. Liss, Inc., 77-96, 1985). For cell based immunizations using cell lines expressing RG1, subtractive immunization may be used to immunotolerize the animals to the parent cell line (Sleister, H. M. and Rao, A. G., *J. Immunological Methods* 261:213-220, 2002).

In addition, techniques developed for the production of "chimeric antibodies", the splicing of mouse antibody genes to human antibody genes to obtain a molecule with appropriate antigen specificity and biological activity can be used (Morrison et al., *Proc. Natl. Acad. Sci. USA* 81:6851-6855, 1984; Neuberger et al., *Nature* 312:604-608, 1984; Takeda et al., *Nature* 314:452-454, 1985). Alternatively, techniques described for the production of single chain antibodies (U.S. Pat. No. 4,946,778) can be adapted to produce RG1-specific single chain antibodies.

Furthermore, "human" antibodies can be produced using the methods described in U.S. Patent Nos. 5,877,397 and 5,569,825, which are incorporated herein in full by reference, or through use of the Xenomouse™, as described in Mendez et al. *Nature Genetics* 15:146-156, 1997. Such antibodies can also be generated using phage display technology (Rader et al., *Current Opinion in Biotechnology* 8:155-168, 1997; Aujame et al., *Human Antibodies* 8:155-168, 1997). The generation of human antibodies is very attractive, in that such antibodies are expected to minimize the immunogenic and allergic responses intrinsic to mouse or mouse-derived monoclonal antibodies. Generation of human antibodies which recognize epitopes of the RG1 polypeptide (SEQ ID NO: 2) are described in Example 4.

Antibodies may also be produced by inducing *in vivo* production in the lymphocyte population or by screening recombinant immunoglobulin libraries or panels of highly specific binding reagents as disclosed in Orlandi et al. (*Proc. Natl. Acad. Sci. USA* 86:3833-3837, 1989) and Winter and Milstein (*Nature* 349:293-299, 1991).

Antibody fragments which contain specific binding sites for RG1 may also be generated. There are often advantages to using antibody fragments, rather than whole antibodies, since the smaller size of the fragments can lead to more rapid clearance, and may also provide improved access to solid tumors.

Such fragments include, but are not limited to the F(ab')₂ fragments which can be produced by pepsin digestion of the antibody molecule and the Fab fragments which can be generated by reducing the disulfide bridges of the F(ab')₂ fragments. Alternatively, Fab expression libraries may be constructed to allow rapid and easy identification of monoclonal Fab fragments with the desired specificity (Huse et al., *Science* 256:1270-1281, 1989). Fab, Fv and ScFv antibody fragments can all be expressed in and secreted from *E. coli*, allowing for the production of large amounts of these fragments. Alternatively, Fab'-SH fragments can be directly recovered from *E. coli* and chemically coupled to form F(ab')₂ fragments (Carter et al., *Bio/Technology* 10:163-167 (1992)). Other techniques for the production of antibody fragments are known to those skilled in the art. Single chain Fv fragments (scFv) are also envisioned (see U.S. Patent No. 5,576,189 and 5,587,458). Fv and sFv fragments are the only species with intact combining sites that are devoid of constant regions; thus, they are likely to show reduced nonspecific

binding during *in vivo* use, and are particularly preferred for use as imaging agents (C. A. K Borrebaeck, editor (1995) *Antibody Engineering (Breakthroughs in Molecular Biology)*, Oxford University Press; R. Kontermann & S. Duebel, editors (2001) *Antibody Engineering (Springer Laboratory Manual)*, Springer Verlag). The antibody fragment may also be a "linear antibody". e.g., as described in U.S. Patent No.

5 5,641,870, for example. Such linear antibody fragments may be monospecific or bispecific.

Variants of the antibodies or antibody fragments described herein are also contemplated, and can be made using any of the techniques and guidelines for conservative and non-conservative mutations, e.g. U.S. Patent No. 5,364,934. Variations include substitution, deletion or insertion of one or more codons encoding the antibody, resulting in a change in the amino acid sequence as compared with the native
10 antibody sequence. The utility of such variations contemplated would include those leading to (1) a reduction in susceptibility to proteolysis or inactivation by oxidation, (2) an alteration in binding affinity for forming protein complexes or binding affinities to antigens, (3) an alteration in *in vivo* clearance or biodistribution, (4) changes in the antibody isotype or allotype, (5) changes in the functional properties of the antibody, for example Fc receptor binding, (6) an alteration in epitope sequences to decrease or
15 increase immunogenicity, and (7) other changes in physicochemical or functional properties of such analogs. Guidance in determining which amino acid residue may be inserted, substituted or deleted without adversely affecting the desired activity may be found by minimizing the number of amino acid sequence changes made in regions of high homology between the RG1 antibodies and that of homologous proteins. The variation allowed may be determined by systematically making insertions,
20 deletions or substitutions of amino acids in the sequence and testing the resulting variants for activity exhibited by the native sequence.

A particularly preferred type of substitutional variant involves substituting one more hypervariable region residues of a parent antibody (e.g. human antibody). Generally, the resulting variant(s) selected for further development will have improved biological properties relative to the parent antibody from which
25 they are generated. A convenient way for generating such substitutional variants involves affinity maturation using phage display (Schier R., *J. Mol. Biol.*, 263:551-67, 1996). The variants are then screened for their biological activity (e.g. binding affinity) as described herein (see Example 4). In order to identify hypervariable region residues which would be good candidates for modification, alanine scanning mutagenesis can be performed to identify hypervariable region residues contributing significantly to
30 antigen binding. Antibodies with superior properties in one or more relevant assays can undergo further development.

The amino acid sequence of RG1 (SEQ ID NO: 2) presented herein may be used to select specific regions of the RG1 polypeptide for generating antibodies. As will be understood by those skilled in the art, the regions or epitopes of an RG1 polypeptide to which an antibody is directed may vary with the
35 intended application. For example, antibodies intended for use in an immunoassay for the detection of membrane-bound RG1 on prostate cells should be directed toward accessible epitopes on the RG1 polypeptide. Regions of the RG1 polypeptide that show immunogenic structure, as well as other regions

and domains, can readily be identified using various other methods known in the art, such as Chou-Fasman, Garnier-Robson, or Jameson-Wolf analysis. Fragments containing these residues are particularly suited in generating anti-RG1 antibodies. Useful fragments include, but are not limited to, the sequences PLGGESICSAGAPAKYSIT (SEQ ID NO: 8); HSSDYSMWRKNQYVS (SEQ ID NO: 10);
5 DAGTDSGFTFSSPNFATIPQDTV (SEQ ID NO: 11); and NEIVDSASVPET (SEQ ID NO: 12). Generation of polyclonal antibodies to these regions is described in Example 4.

Uses of Antibodies Recognizing Epitopes of RG1

The antibodies, antigen-binding antibody fragments, and variants thereof of the invention may
10 be particularly useful in diagnostic assays, imaging methodologies, and therapeutic methods for the management of prostate cancer.

The invention provides various immunological assays useful for the detection of RG1 polypeptides and for the diagnosis of prostate cancer. Such assays generally comprise one or more RG1 antibodies capable of recognizing and binding a RG1 polypeptide. The most preferred antibodies
15 will selectively bind to RG1 and will not bind (or bind weakly) to non-RG1 polypeptides. The assays include various immunological assay formats well known in the art, including but not limited to various types of radioimmunoassays, enzyme-linked immunoabsorbent assays, and the like. In addition, immunological imaging methods capable of detecting prostate cancer are also provided by the invention; including but not limited to radioscintigraphic imaging methods using labeled RG1 antibodies.
20 Such assays may be clinically useful in the detection, monitoring and prognosis of prostate cancer.

The above-described antibodies may be employed to isolate or to identify clones expressing the polypeptide or to purify the polypeptide of the present invention by attachment of the antibody to a solid support for isolation and/or purification by affinity chromatography.

Additionally, RG1 antibodies may be used to isolate RG1 positive cells using cell sorting and
25 purification techniques. In particular, RG1 antibodies may be used to isolate prostate cancer cells from xenograft tumor tissue, from cells in culture, etc. using antibody-based cell sorting or affinity purification techniques. Other uses of the RG1 antibodies of the invention include generating anti-idiotypic antibodies that mimic the RG1 polypeptide.

RG1 antibodies can be used for detecting the presence of prostate cancer or tumor metastasis.
30 The presence of such RG1-containing cells within various biological samples, including serum, prostate and other tissue biopsy specimens, may be detected with RG1 antibodies. In addition, RG1 antibodies may be used in various imaging methodologies such as immunoscintigraphy with a ^{99m}Tc (or other isotope) conjugated antibody. For example, an imaging protocol similar to the one recently described using an ¹¹¹In conjugated anti-PSMA antibody may be used to detect recurrent and metastatic prostate
35 carcinomas (Sodee et al., *Clin. Nuc. Med.* 21: 759-766, 1997). Another method of detection that can be used is positron emitting tomography (see Herzog et al., *J. Nucl. Med.* 34:2222-2226, 1993)

The RG1 antibodies of the invention may be labeled with a detectable marker or conjugated to a

second molecule, such as a cytotoxic agent, and used for targeting the second molecule to a RG1 positive cell (Vitetta, E.S. et al., *Immunotoxin Therapy*, in DeVita, Jr, V.T. et al., eds, *Cancer: Principles and Practice of Oncology*, 4th ed., J.B. Lippincott Co., Philadelphia, 2624-2636, 1993). Examples of cytotoxic agents include, but are not limited to ricin, doxorubicin, daunorubicin, taxol, ethidium bromide, mitomycin, etoposide, tenoposide, vincristine, vinblastine, colchicine, dihydroxy anthracin dione, actinomycin D, diphtheria toxin, epothilones, *Pseudomonas* exotoxin (PE) A, PE40, abrin, and glucocorticoid and other chemotherapeutic agents, as well as radioisotopes. Cytotoxic or antiproliferative targeted fusion proteins may be created by genetic or chemical fusion of the antibody to an appropriate cytokine, chemokine, interferon, or growth factor that has the desired anti-tumor biological activity (Asgeirsdottir et al., *Biochem. Pharmacol.* 15:1729-1739, 2003). Suitable detectable markers include, but are not limited to, a radioisotope, a fluorescent compound, a bioluminescent compound, chemiluminescent compound, a metal chelator or an enzyme. Suitable radioisotopes for immunotherapy or for use as a detectable marker include the following: Antimony-124, Antimony-125, Arsenic-74, Barium-103, Barium-140, Beryllium-7, Bismuth-206, Bismuth-207, Cadmium-109, Cadmium-115m, Calcium-45, Cerium-139, Cerium-141, Cerium-144, Cesium-137, Chromium-51, Cobalt-56, Cobalt-57, Cobalt-58, Cobalt-60, Cobalt-64, Erbium-169, Europium-152, Gadolinium-153, Gold-195, Gold-199, Hafnium-175, Hafnium-181, Indium-111, Iodine-123, Iodine-131, Iridium-192, Iron-55, Iron-59, Krypton-85, Lead-210, Lutetium-177, Manganese-54, Mercury-197, Mercury-203, Molybdenum-99, Neodymium-147, Neptunium-237, Nickel-63, Niobium-95, Osmium-185+191, Palladium-103, Platinum-195m, Praseodymium-143, Promethium-147, Protactinium-233, Radium-226, Rhenium-186, Rubidium-86, Ruthenium-103, Ruthenium-106, Scandium-44, Scandium-46, Selenium-75, Silver-110m, Silver-111, Sodium-22, Strontium-85, Strontium-89, Strontium-90, Sulfur-35, Tantalum-182, Technetium-99m, Tellurium-125, Tellurium-132, Thallium-170, Thallium-204, Thorium-228, Thorium-232, Tin-113, Titanium-44, Tungsten-185, Vanadium-48, Vanadium-49, Ytterbium-169, Yttrium-88, Yttrium-90, Zinc-65, and Zirconium-95.

Radiolabeling of antibodies is accomplished using a chelating agent which is covalently attached to the antibody, with the radionuclide inserted into the chelating agent. Preferred chelating agents are set forth in Srivastava et al. *Nucl. Med. Bio.* 18:589-603, 1991 and McMurtry et al., *J. Med. Chem.* 41:3546-3549, 1998. or derived from the so-called NOTA chelate published in H. Chong, K. et al., *J. Med. Chem.* 45:3458-3464, 2002, all of which are incorporated herein in full by reference. Particularly preferred for conjugation of radioisotopes to an RG1 antibody are derivatives of the bifunctional chelator p-SCN-Benzyl-DTPA (Brechtel et al. *Inorg. Chem.* 25:2772-2781, 1986); for example, cyclohexyl-DTPA (CHX-A''-DTPA, Wu et al., *Bioorg. Med. Chem.* 10:1925-1934, 1997) and MX-DTPA (1B4M-DTPA, McMurtry et al., *J. Med. Chem.*, 41: 3546-3549, 1998), as well as 1,4,7-triazacyclononane-N,N',N''-triacetic acid (NOTA) (Chong et al. *J. Med. Chem.* 45:3458-3464, 2002). Conjugation can be accomplished by the method of Nikula et al. *Nucl. Med. Biol.* 3:387-390, 1995. Particularly preferred for use as a detectable marker for immunoscintigraphy are the radioisotopes ¹¹¹In

or ^{99m}Tc . Preferred detectable markers for positron emitting tomography are ^{43}Sc , ^{44}Sc , ^{52}Fe , ^{55}Co , ^{68}Ga , ^{64}Cu , ^{86}Y and ^{94m}Tc . For immunotherapy, the beta-emitting radioisotopes ^{46}Sc , ^{47}Sc , ^{48}Sc , ^{72}Ga , ^{73}Ga , ^{90}Y , ^{67}Cu , ^{109}Pd , ^{111}Ag , ^{149}Pm , ^{153}Sm , ^{166}Ho , ^{177}Lu , ^{186}Re , and ^{188}Re and the alpha-emitting isotopes ^{211}At , ^{211}Bi , ^{212}Bi , ^{213}Bi and ^{214}Bi , can be used. Preferred are ^{90}Y , ^{177}Lu , ^{72}Ga , ^{153}Sm , ^{67}Cu and ^{212}Bi , and particularly preferred are ^{90}Y and ^{177}Lu .

Immunotherapy for Prostate Cancer

The invention provides various immunotherapeutic methods for treating prostate cancer, including antibody therapy, *in vivo* vaccines, and *ex vivo* immunotherapy approaches. In one approach, the invention provides RG1 antibodies which may be used systemically to treat prostate cancer. For example, unconjugated RG1 antibodies may be introduced into a patient such that the antibody binds to RG1 on, in or associated with prostate cancer cells and mediates the destruction of the cells, and the tumor, by mechanisms which may include complement-mediated cytotoxicity, antibody-dependent cellular cytotoxicity, altering the physiologic function of RG1, and/or the inhibition of ligand binding or signal transduction pathways. RG1 antibodies conjugated to toxic agents such as ricin or radioisotopes may also be used therapeutically to deliver the toxic agent directly to RG1-bearing prostate tumor cells and thereby destroy the tumor cells.

Prostate cancer immunotherapy using RG1 antibodies may follow the teachings generated from various approaches which have been successfully employed with respect to other types of cancer, including but not limited to colon cancer (Arlen et al., *Crit. Rev. Immunol.* 18: 133-138, 1998), multiple myeloma (Ozaki et al., *Blood* 90: 3179-3186, 1997; Tsunenari et al., *Blood* 90: 2437-2444, 1997), gastric cancer (Kasprzyk et al., *Cancer Res.* 52: 2771-2776, 1992), B-cell lymphoma (Funakoshi et al., *Immunother. Emphasis Tumor Immunol.* 19: 93-101, 1996), leukemia (Zhong et al., *Leuk. Res.* 20: 581-589, 1996), colorectal cancer (Moun et al., *Cancer Res.* 54: 6160-6166, 1994; Velders et al., *Cancer Res.* 55:4398-4403, 1995), and breast cancer (Shepard et al., *J. Clin. Immunol.* 11: 117-127, 1991).

The invention further provides vaccines formulated to contain an RG1 polypeptide or fragment thereof. The use of a tumor antigen in a vaccine for generating humoral and cell-mediated immunity for use in anti-cancer therapy is well known in the art and has been employed in prostate cancer using human PSMA and rodent PAP immunogens (Hodge et al., *Int. J. Cancer* 63: 231-237, 1995; Fong et al., *J. Immunol.* 159: 3113-3117, 1997). Such methods can be readily practiced by employing a RG1 polypeptide, or fragment thereof, or a RG1-encoding nucleic acid molecule and recombinant vectors capable of expressing and appropriately presenting the RG1 immunogen.

For example, viral gene delivery systems may be used to deliver a RG1-encoding nucleic acid molecule. Various viral gene delivery systems which can be used in the practice of this aspect of the invention include, but are not limited to, vaccinia, fowlpox, canarypox, adenovirus, influenza, poliovirus, adeno-associated virus, lentivirus, and sindbus virus (Restifo, in *Curr. Opin. Immunol.* 8: 658-663, 1996). Non-viral delivery systems may also be employed by using naked DNA encoding a RG1

polypeptide or fragment thereof introduced into the patient (i.e., intramuscularly) to induce an anti-tumor response. In one embodiment, the full-length human *rg1* cDNA may be employed. In another embodiment, human *rg1* cDNA fragments may be employed. In another embodiment, *rg1* nucleic acid molecules encoding specific T lymphocyte (CTL) epitopes may be employed. CTL epitopes can be determined using specific algorithms (e.g., Epimer, Brown University) to identify peptides within a RG1 polypeptide which are capable of optimally binding to specified HLA alleles.

Various *ex vivo* strategies may also be employed. One approach involves the use of dendritic cells to present a RG1 polypeptide as antigen to a patient's immune system. Dendritic cells express MHC class I and II, B7 costimulator, and IL-12, and are thus highly specialized antigen presenting cells. In prostate cancer, autologous dendritic cells pulsed with peptides of the prostate-specific membrane antigen (PSMA) are being used in a Phase I clinical trial to stimulate prostate cancer patients' immune systems (Tjoa et al., *Prostate* 28: 65-69, 1996; Murphy et al., *Prostate* 29: 371-380, 1996). Dendritic cells can be used to present RG1 polypeptides to T cells in the context of MHC class I and II molecules. In one embodiment, autologous dendritic cells are pulsed with RG1 polypeptides capable of binding to MHC molecules. In another embodiment, dendritic cells are pulsed with the complete RG1 polypeptide. Yet another embodiment involves engineering the overexpression of the *rg1* gene in dendritic cells using various implementing vectors known in the art, such as adenovirus (Arthur et al., *Cancer Gene Ther.* 4: 17-25, 1997), retrovirus (Henderson et al., *Cancer Res.* 56: 3763-3770, 1996), lentivirus, adeno-associated virus, DNA transfection (Ribas et al., *Cancer Res.* 57: 2865-2869, 1997), and tumor-derived RNA transfection (Ashley et al., *J. Exp. Med.* 186: 1177-1182, 1997).

Anti-idiotypic anti-RG1 antibodies can also be used in anti-cancer therapy as a vaccine for inducing an immune response to cells expressing an RG1 polypeptide. Specifically, the generation of anti-idiotypic antibodies is well known in the art and can be readily adapted to generate anti-idiotypic anti-RG1 antibodies that mimic an epitope on a RG1 polypeptide (see, for example, Wagner et al., *Hybridoma* 16: 33-40, 1997; Foon et al., *J. Clin. Invest.* 96: 334-342, 1995; Herlyn et al., *Cancer Immunol Immunother* 43: 65-76, 1996). Such an anti-idiotypic antibody can be used in anti-idiotypic therapy as presently practiced with other anti-idiotypic antibodies directed against tumor antigens.

Genetic immunization methods may be employed to generate prophylactic or therapeutic humoral and cellular immune responses directed against cancer cells expressing RG1. Using the RG1-encoding DNA molecules described herein, constructs comprising DNA encoding an RG1 polypeptide/immunogen and appropriate regulatory sequences may be injected directly into muscle or skin of an individual, such that the cells of the muscle or skin take up the construct and express the encoded RG1 polypeptide/immunogen. The RG1 polypeptide/immunogen may be expressed as a cell surface polypeptide or be secreted. Expression of the RG1 polypeptide/immunogen results in the generation of prophylactic or therapeutic humoral and cellular immunity against prostate cancer. Various prophylactic and therapeutic genetic immunization techniques known in the art may be used (for a review, see information and references published at internet address www.genweb.com).

Anti-sense oligonucleotides, antisense vectors, and ribozymes

Anti-sense polynucleotides complementary to *rg1* may be prepared synthetically. Such oligonucleotides may be delivered into cells with or without lipids that may assist uptake of the anti-sense oligonucleotides into cells.

5 Alternatively, expression vectors derived from retroviruses, adenovirus, herpes or vaccinia viruses, or from various bacterial plasmids, may also be used for construction and delivery of recombinant vectors which will express anti-sense *rg1*. See, for example, the techniques described in Sambrook et al. (*supra*) and Ausubel et al. (*supra*).

10 The polynucleotides comprising the full length cDNA sequence and/or its regulatory elements enable researchers to use *rg1* polynucleotides as an investigative tool in sense strands (Yousoufian and Lodish, *Mol. Cell. Biol.* 13:98-104, 1993) or antisense strands (Eguchi, et al., *Annu. Rev. Biochem.* 60:631-652, 1991) for the regulation of gene function. Such technology is now well known in the art, and sense or antisense oligomers, or larger fragments, can be designed from various locations along the coding or control regions.

15 Genes encoding RG1 can be turned off by transfecting a cell or tissue with expression vectors which express high levels of a desired *rg1* polynucleotide fragment. Such constructs can flood cells with untranslatable sense or antisense sequences. Even in the absence of integration into the DNA, such vectors may continue to transcribe RNA molecules until all copies are disabled by endogenous nucleases. Transient expression may last for a month or more with a non-replicating vector and even longer if
20 appropriate replication elements are part of the vector system.

As mentioned above, modification of gene expression can be obtained by designing antisense molecules, DNA or RNA, to control regions of *rg1*, i.e., the promoters, enhancers, and introns. Oligonucleotides derived from the transcription initiation site, e.g. between -10 and +10 regions of the leader sequence, are preferred. The antisense molecules may also be designed to block translation of
25 mRNA by preventing the transcript from binding to ribosomes. Similarly, inhibition can be achieved using "triple helix" base-pairing methodology. Triple helix pairing compromises the ability of the double helix to open sufficiently for the binding of polymerases, transcription factors, or regulatory molecules. Recent therapeutic advances using triplex DNA were reviewed by Gee, J.E. et al. (In Huber and Car, *Molecular and Immunologic Approaches*, Futura Publishing Co., Mt. Kisco, N.Y., 1994).

30 Ribozymes are enzymatic RNA molecules capable of catalyzing the specific cleavage of RNA (U.S. Patent No. 4,987,071; WO 93/23057). The mechanism of ribozyme action involves sequence-specific hybridization of the ribozyme molecule to complementary target RNA, followed by endonucleolytic cleavage. Within the scope of the invention are engineered hammerhead motif ribozyme molecules that can specifically and efficiently catalyze endonucleolytic cleavage of RNA encoding RG1. Specific
35 ribozyme cleavage sites within any potential RNA target are initially identified by scanning the target molecule for ribozyme cleavage sites which include the following sequences, GUA, GUU and GUC. Once identified, short RNA sequences of between 15 and 20 ribonucleotides corresponding to the region of the

target gene containing the cleavage site may be evaluated for secondary structural features which may render the oligonucleotide inoperable. The suitability of candidate targets may also be evaluated by testing accessibility to hybridization with complementary oligonucleotides using ribonuclease protection assays (Irie et al., *Advanc. Pharmacol.* 40:207-257, 1997).

5 Antisense molecules and ribozymes of the invention may be prepared by any method known in the art for the synthesis of RNA molecules. These include techniques for chemically synthesizing oligonucleotides such as solid phase phosphoramidite chemical synthesis. Alternatively, RNA molecules may be generated by *in vitro* and *in vivo* transcription or by DNA sequences encoding RG1. Such DNA sequences may be incorporated into a wide variety of vectors with suitable RNA polymerase promoters
10 such as T7 or SP6. Alternatively, antisense cDNA constructs that synthesize antisense RNA constitutively or inducibly can be introduced into cell lines, cells or tissues.

RNA molecules may be modified to increase intracellular stability and half-life. Possible modifications include, but are not limited to, the addition of flanking sequences at the 5' and/or 3' ends of the molecules or the use of phosphorothioate or 2' O-methyl rather than phosphodiesterase linkages
15 within the backbone of the molecule. Increased stability can also be achieved by the inclusion of nontraditional bases such as inosine and queosine as well as acetyl-, methyl-, thio- and similarly modified forms of adenine, cytidine, guanine, thymine, and uridine which are not as easily recognized by endogenous endonucleases.

Methods for introducing antisense vectors into cells or tissues include those methods discussed
20 *infra* and which are equally suitable for *in vivo*, *in vitro* and *ex vivo* therapy. For *ex vivo* therapy, antisense vectors are introduced into cells taken from the patient and clonally propagated for autologous transplant back into that same patient as presented in U.S. Pat. Nos. 5,399,493 and 5,437,994, disclosed herein by reference. Delivery by transfection and by liposome or other lipid based or non-lipid based agents are well known in the art.

Assays for Identifying Agents Binding to RG1

The present invention also relates to assays and methods which can be used to identify
25 agents (i.e. an antibody, peptide, etc.) that bind to RG1. Specifically, agents that bind to RG1 can be identified by the ability of the RG1 ligand or other agent or constituent to bind to RG1 and/or the ability
30 to inhibit/stimulate RG1 activity.

Alternatively, agents that bind to an RG1 polypeptide can be identified using a yeast two-hybrid system or a binding capture assay. In the yeast two hybrid system, an expression unit encoding a fusion protein made up of one subunit of a two subunit transcription factor and the RG1 polypeptide is introduced and expressed in a yeast cell. The cell is further modified to contain (1) an expression unit
35 encoding a detectable marker whose expression requires the two subunit transcription factor for expression and (2) an expression unit that encodes a fusion protein made up of the second subunit of the transcription factor and a cloned segment of DNA. If the cloned segment of DNA encodes a protein

that binds to the RG1 polypeptide, the expression results in the interaction of RG1 and the encoded protein. This brings the two subunits of the transcription factor into binding proximity, allowing reconstitution of the transcription factor. This results in expression of the detectable marker. The yeast two hybrid system is particularly useful in screening a library of cDNA encoding segments for cellular binding partners of RG1.

RG1 polypeptides which may be used in the above assays include, but are not limited to, an isolated RG1 polypeptide, a fragment of a RG1 polypeptide, a cell that has been altered to express a RG1 polypeptide, or a fraction of a cell that has been altered to express a RG1 polypeptide. Further, the RG1 polypeptide can be the entire polypeptide or a defined fragment of the RG1 polypeptide. It will be apparent to one of ordinary skill in the art that so long as the RG1 polypeptide can be assayed for agent binding, e.g. by a shift in molecular weight or activity, the present assay can be used.

The method used to identify whether an agent/cellular component binds to a RG1 polypeptide will be based primarily on the nature of the RG1 polypeptide used. For example, a gel retardation assay can be used to determine whether an agent binds to RG1 or a fragment thereof. Alternatively, immunodetection and biochip technologies can be adopted for use with the RG1 polypeptide. A skilled artisan can readily employ numerous art-known techniques for determining whether a particular agent binds to an RG1 polypeptide.

Agents and cellular components can be further tested for the ability to modulate the activity of an RG1 polypeptide using a cell-free assay system or a cellular assay system. As the activities of the RG1 polypeptide become more defined, functional assays based on the identified activity can be employed.

As used herein, an agent is said to antagonize RG1 activity when the agent reduces RG1 activity. The preferred antagonist will selectively antagonize RG1, not affecting any other cellular proteins. Further, the preferred antagonist will reduce RG1 activity by more than 50%, more preferably by more than 90%, most preferably eliminating all RG1 activity.

Agents that are assayed in the above method can be randomly selected or rationally selected or designed. As used herein, an agent is said to be randomly selected when the agent is chosen randomly without considering the specific sequences of the RG1 polypeptide. An example of randomly selected agents is the use of a chemical library or a peptide combinatorial library, or growth broth of an organism or plant extract.

As used herein, an agent is said to be rationally selected or designed when the agent is chosen on a nonrandom basis that takes into account the sequence of the target site and/or its conformation in connection with the agent's action. Agents can be rationally selected or rationally designed by utilizing the peptide sequences that make up the RG1 polypeptide. For example, a rationally selected peptide agent can be a peptide whose amino acid sequence is identical to a fragment of an RG1 polypeptide.

The agents tested in the methods of the present invention can be, as examples, peptides, antibodies, oligonucleotides, small molecules and vitamin derivatives, as well as carbohydrates. A

skilled artisan can readily recognize that there is no limit as to the structural nature of the agents used in the present screening method. One class of agents of the present invention are peptide agents whose amino acid sequences are chosen based on the amino acid sequence of the RG1 polypeptide.

Peptide agents can be prepared using standard solid phase (or solution phase) peptide synthesis methods, as is known in the art. In addition, the DNA encoding these peptides may be synthesized using commercially available oligonucleotide synthesis instrumentation and produced recombinantly using standard recombinant production systems. The production using solid phase peptide synthesis is necessitated if no-gene-encoded amino acids are to be included.

Another class of agent of the present invention are antibodies immunoreactive with critical positions of the RG1 polypeptide. As described above, antibodies are obtained by immunization of suitable mammalian subjects with peptides, containing as antigenic regions, those portions of the RG1 polypeptide intended to be targeted by the antibodies. Such agents can be used in competitive binding studies to identify second generation inhibitory agents as well as to block RG1 activity.

The cellular extracts tested in the methods of the present invention can be, as examples, aqueous extracts of cells or tissues, organic extracts of cells or tissues or partially purified cellular fractions. A skilled artisan can readily recognize that there is no limit as to the source of the cellular extract used in the screening method of the present invention.

Agents that bind a RG1 polypeptide, such as a RG1 antibody, can be used to modulate the activity of RG1, to target anticancer agents to appropriate mammalian cells, or to identify agents that block the interaction with RG1. Cells expressing RG1 can be targeted or identified by using an agent that binds to RG1.

How the RG1 binding agents will be used depends on the nature of the RG1 binding agent. For example, a RG1 binding agent can be used to: deliver conjugated toxins, such as diphtheria toxin, cholera toxin, ricin or pseudomonas exotoxin, to a RG1 expressing cell; modulate RG1 activity; to directly kill a RG1 expressing cell; or in screens to identify competitive binding agents. For example, a RG1 inhibitory agent can be used to directly inhibit the growth of RG1 expressing cells whereas a RG1 binding agent can be used as a diagnostic agent.

Pharmaceutical Compositions and Administration

The present invention also relates to pharmaceutical compositions which may comprise *rg1* polynucleotides, RG1 polypeptides, antibodies, agonists, antagonists, or inhibitors, alone or in combination with at least one other agent, such as stabilizing compound, which may be administered in any sterile, biocompatible pharmaceutical carrier, including, but not limited to, saline, buffered saline, dextrose, and water. Any of these molecules can be administered to a patient alone, or in combination with other agents, drugs or hormones, in pharmaceutical compositions where it is mixed with excipient(s) or pharmaceutically acceptable carriers. In one embodiment of the present invention, the pharmaceutically acceptable carrier is pharmaceutically inert.

The present invention also relates to the administration of pharmaceutical compositions. Such administration is accomplished orally or parenterally. Methods of parenteral delivery include topical, intra-arterial (directly to the tumor), intramuscular, subcutaneous, intramedullary, intrathecal, intraventricular, intravenous, intraperitoneal, or intranasal administration. In addition to the active ingredients, these

5 pharmaceutical compositions may contain suitable pharmaceutically acceptable carriers comprising excipients and auxiliaries which facilitate processing of the active compounds into preparations which can be used pharmaceutically. Further details on techniques for formulation and administration may be found in the latest edition of *Remington's Pharmaceutical Sciences* (Ed. Maack Publishing Co, Easton, Pa.).

Pharmaceutical compositions for oral administration can be formulated using pharmaceutically

10 acceptable carriers well known in the art in dosages suitable for oral administration. Such carriers enable the pharmaceutical compositions to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspensions and the like, for ingestion by the patient.

Pharmaceutical preparations for oral use can be obtained through combination of active

15 compounds with solid excipient, optionally grinding a resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired, to obtain tablets or dragee cores. Suitable excipients are carbohydrate or protein fillers such as sugars, including lactose, sucrose, mannitol, or sorbitol; starch from corn, wheat, rice, potato, or other plants; cellulose such as methyl, cellulose, hydroxypropylmethylcellulose, or sodium carboxymethylcellulose; and gums including arabic and tragacanth; and proteins such as gelatin and collagen. If desired, disintegrating or solubilizing agents may

20 be added, such as the cross-linked polyvinyl pyrrolidone, agar, alginic acid, or a salt thereof, such as sodium alginate.

Dragee cores are provided with suitable coatings such as concentrated sugar solutions, which may also contain gum arabic, talc, polyvinylpyrrolidone, carbopol gel, polyethylene glycol and/or titanium dioxide, lacquer solutions, and suitable organic solvents or solvent mixtures. Dyestuffs or pigments may

25 be added to the tablets or dragee coatings for product identification or to characterize the quantity of active compound, ie. dosage.

Pharmaceutical preparations that can be used orally include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a coating such as glycerol or sorbitol. Push-fit capsules can contain active ingredients mixed with a filler or binders such as lactose or starches, lubricants such as

30 talc or magnesium stearate, and optionally, stabilizers. In soft capsules, the active compounds may be dissolved or suspended in suitable liquids, such as fatty oils, liquid paraffin, or liquid polyethylene glycol with or without stabilizers.

Pharmaceutical formulations for parenteral administration include aqueous solutions of active compounds. For injection, the pharmaceutical compositions of the invention may be formulated in

35 aqueous solutions, preferably in physiologically compatible buffers such as Hank's solution, Ringer's solution, or physiologically buffered saline. Aqueous injection suspensions may contain substances that increase viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, or dextran.

Additionally, suspensions of the active compounds may be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl oleate or triglycerides, or liposomes. Optionally, the suspension may also contain suitable stabilizers or agents which increase the solubility of the compounds to allow for the preparation of highly concentrated solutions.

For topical or nasal administration, penetrants appropriate to the particular barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

Kits

The invention further relates to pharmaceutical packs and kits comprising one or more containers filled with one or more of the ingredients of the aforementioned compositions of the invention. Associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, reflecting approval by the agency of the manufacture, use or sale of the product for human administration.

Manufacture and Storage.

The pharmaceutical compositions of the present invention may be manufactured in a manner that is known in the art, e.g., by means of conventional mixing, dissolving, granulating, dragee-making, levigating, emulsifying, encapsulating, entrapping or lyophilizing processes.

The pharmaceutical composition may be provided as a salt and can be formed with many acids, including but not limited to hydrochloric, sulfuric, acetic, lactic, tartaric, malic, succinic, etc. Salts tend to be more soluble in aqueous or other protonic solvents than are the corresponding free base forms. In other cases, the preferred preparation may be a lyophilized powder in 1mM-50 mM histidine, 0.1%-2% sucrose, 2%-7% mannitol at a pH range of 4.5 to 5.5 that is combined with buffer prior to use.

After pharmaceutical compositions comprising a compound of the invention formulated in an acceptable carrier have been prepared, they can be placed in an appropriate container and labeled for treatment of an indicated condition. For administration of RG1, such labeling would include amount, frequency and method of administration.

Therapeutically Effective Dose.

Pharmaceutical compositions suitable for use in the present invention include compositions wherein the active ingredients are contained in an effective amount to achieve the intended purpose, i.e. treatment of a particular disease state characterized by RG1 expression. The determination of an effective dose is well within the capability of those skilled in the art.

For any compound, the therapeutically effective dose can be estimated initially either in cell culture assays, e.g., neoplastic cells, or in animal models, usually mice, rabbits, dogs, or pigs. The animal

model is also used to achieve a desirable concentration range and route of administration. Such information can then be used to determine useful doses and routes for administration in humans.

A therapeutically effective dose refers to that amount of protein or its antibodies, antagonists, or inhibitors that ameliorate the symptoms or condition. Therapeutic efficacy and toxicity of such compounds can be determined by standard pharmaceutical procedures in cell cultures or experimental animals, e.g., ED₅₀ (the dose therapeutically effective in 50% of the population) and LD₅₀ (the dose lethal to 50% of the population). The dose ratio between therapeutic and toxic effects is the therapeutic index, and it can be expressed as the ratio, ED₅₀/LD₅₀. Pharmaceutical compositions that exhibit large therapeutic indices are preferred. The data obtained from cell culture assays and animal studies is used in formulating a range of dosage for human use. The dosage of such compounds lies preferably within a range of circulating concentrations what include the ED₅₀ with little or no toxicity. The dosage varies within this range depending upon the dosage form employed, sensitivity of the patient, and the route of administration.

The exact dosage is chosen by the individual physician in view of the patient to be treated. Dosage and administration are adjusted to provide sufficient levels of the active moiety or to maintain the desired effect. Additional factors that may be taken into account include the severity of the disease state, eg, tumor size and location; age, weight and gender of the patient; diet, time and frequency of administration, drug combination(s), reaction sensitivities, and tolerance/response to therapy. Long acting pharmaceutical compositions might be administered every 3 to 4 days, every week, or once every two weeks depending on half-life and clearance rate of the particular formulation.

Normal dosage amounts may vary from 0.1 to 100,000 micrograms, up to a total dose of about 1 g, depending upon the route of administration. Guidance as to particular dosages and methods of delivery is provided in the literature. See U.S. Pat. Nos. 4,657,760; 5,206,344; or 5,225,212. Those skilled in the art will employ different formulations for polynucleotides than for proteins or their inhibitors. Similarly, delivery of polynucleotides or polypeptides will be specific to particular cells, conditions, locations, etc. Preferred specific activities for for a radiolabeled antibody may range from 0.1 to 10 mCi/mg of protein (Riva et al., *Clin. Cancer Res.* 5:3275s-3280s, 1999; Wong et al., *Clin. Cancer Res.* 6:3855-3863, 2000; Wagner et al., *J. Nuclear Med.* 43:267-272, 2002).

The present invention is further described by the following examples. The examples are provided solely to illustrate the invention by reference to specific embodiments. These exemplifications, while illustrating certain specific aspects of the invention, do not portray the limitations or circumscribe the scope of the disclosed invention.

All examples were carried out using standard techniques, which are well known and routine to those of skill in the art, except where otherwise described in detail. Routine molecular biology techniques of the following examples can be carried out as described in standard laboratory manuals, such as Sambrook et al., *Molecular Cloning: A Laboratory Manual*, 2nd Ed.; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., 1989.

Example 1: Identification of human *rg1* polynucleotide

Rg1 was identified as a gene expressed in the prostate by mining Incyte's LifeSeq® database. The nucleotide sequence was identified by an annotation search of the database, using the "Protein Function" tool provided by Incyte for the purpose of searching the database. The nucleotide sequence was found in the category of cell adhesion molecules in the annotated database and was described as a homologue of f-spondin. Electronic Northern analysis of the distribution of *rg1* polynucleotide sequences in the set of libraries in the database revealed that *rg1* was expressed at high levels in the prostate libraries and at lower levels in a number of other tissue libraries, including those from normal and tumor tissues.

Following assembly of the set of *rg1* clones in the database into a contiguous polynucleotide sequence, and editing of the contiguous sequence, a full-length coding sequence was identified in the predicted assembled polynucleotide. This sequence coded for a protein homologous to f-spondin and to Mindin-2.

Incyte clones 1640796, 1712252, and 1880265 were obtained from Incyte for experimental work and clone 3360733 was identified as containing the most 5' nucleotide sequence. This clone was fully sequenced and contained the full coding sequence for the predicted RG1 protein. This sequence is shown in Figure 1 (SEQ D NO: 1).

Example 2: *Rg1* mRNA Expression

The expression of *rg1* mRNA in a variety of samples from normal and tumor tissues and in cell lines, was determined by semi-quantitative PCR using a Taqman assay, (Perkin-Elmer). Prostate normal, benign and tumor tissue samples that had been graded according to a modified Gleason grading system were obtained from the Urology Department at Stanford University School of Medicine. RNA was isolated from these by standard procedures. RNA from other tumor and normal tissues was purchased from commercial sources, including Clontech, and Biochain. Prostate tumor cell lines, (PC-3, LNCaP and DU145), were obtained from American Type Culture Collection and propagated in culture by standard methods using serum containing medium. Xenograft tumors derived from these cell lines were established in nude mice and harvested from the mice approximately 4-6 weeks after implantation. RNA was isolated from the tumors by standard procedures.

Taqman based PCR analysis was performed using the primers: CGC GCA TAG CTC CGA CTA C (SEQ ID NO: 3) and GCC GCG TCC GCA AAG (SEQ ID NO: 4) and the Taqman probe: 6-FAM-AGG AAG AAC CAG TAC GTC AGT AAC GGG CTG-Tamra (SEQ ID NO: 5).

These primers and probe were designed using Perkin Elmer's Primer Express software and were synthesized by Synthetic Genetics. PCR reactions were carried out for 30-40 cycles and quantified using prostate RNA to generate a standard curve for relative comparison. This analysis demonstrated

that *rg1* mRNA was detected at highest abundance in the prostate and at significantly lower levels in several other tissues (See Figure 5).

5

Example 3: Production of RG1 in BHK cells

Cloning: The RG1 coding region was obtained from Incyte plasmid 3360733. The coding sequence was PCR amplified with primers

SST115 (5' – TCCCTCTAGAGCCACCATGGAAAACCCCAGCCCGGC – 3') (SEQ ID NO: 6) and

10 SST113 (5' – AAGGCATCACGTGTTAGACGCAGTTATCAGGGACG – 3') (SEQ ID NO: 7) in a standard PCR reaction (100ul) using 1x Pfu Turbo polymerase buffer (Stratagene, La Jolla, CA)/200uM dNTPs/0.2uM oligonucleotide primers/ 2.5U Pfu Turbo polymerase (Stratagene). PCR amplification conditions were as follows: 3 mins at 95°C, (15 seconds at 95°C, 30 seconds at 60°C, 2 minutes at 72°C)x35, 72°C for 7 minutes. The resulting PCR amplified product was purified using a QIAquick PCR
15 column (Qiagen, Valencia, CA) and digested with XbaI and PmlI restriction enzymes to result in a 1010 bp fragment that was purified from a 1% agarose gel using a BIO 101 GeneClean Kit (Vista, CA). The purified fragment was ligated (using Epicentre Fast Link Kit, (Epicenter, Madison, WI) to the noncytopathic Sindbis expression vector pSINrep21 (Agapov et al, 1998, *PNAS* 95: 12989-12994) digested with XbaI and PmlI, and transformed into DH5 alpha competent cells (Life Technologies,
20 Gaithersburg, CA) and selected on LB agar plates containing ampicillin (100ug/ml). One such ampicillin resistant colony was grown in LB medium with ampicillin and shown by sequence analysis to contain the inserted RG1 coding sequence. This plasmid was called pPEG6.

Expression: Two micrograms of pPEG6 was used to transfect $1-3 \times 10^5$ bovine hamster kidney cells (BHK) cells using Lipofectamine Plus reagent (Life Technologies, Gaithersburg, MD) according to
25 the manufacturer's instructions. Following transfection, cells were incubated in DMEM plus fetal blood serum for 24-48 hours, at which time the cells were split 1 to 10 and selection for the plasmid containing cells was initiated by adding puromycin (2.5ug/ml final concentration) and DMEM containing serum. After the cells were confluent (4-5 days post puromycin addition) the cells were washed with PBS, split 1 to 10, and DMEM medium with serum and 5ug/ml puromycin was added. After an additional 2-3 days,
30 the medium was replaced with DMEM and 5ug/ml puromycin without serum, grown for 2-3 days and the presence of RG1 protein was detected in the medium by Western analysis using RG1 antibodies. RG1 protein was detected at a level of 1ug/ml.

Purification: Baby hamster kidney cells (BHK), transfected to stably overexpress and secrete RG1 protein into the growth medium, were cultured in medium containing fetal bovine serum. When
35 subconfluent, the cells were switched to serum-free medium for 24-48 hours. The medium was collected, centrifuged to remove cells and stored at -80 degrees C. Media was thawed immediately prior to purification and kept on ice. Protease inhibitors were added, media was diluted ten-fold with cold

20mM Sodium acetate buffer, pH 6.5 and kept at 4 degrees C throughout the purification. The diluted sample was loaded onto a Q-Sepharose anion exchange column at a flow rate of 0.5 ml/min then washed with the same buffer. Elution was performed using a linear NaCl gradient (0-80% of 1M NaCl in buffer, 0.5% per minute) while collecting fractions. The RG1 eluted at approximately 75 mM NaCl, as determined by SDS PAGE and Western blot. RG1 containing fractions were pooled, concentrated by ultrafiltration and further purified over a Superdex 75 gel filtration column. Purified BHK-RG1 was used as immunogen in the generation of human mabs that are specific for native RG1(nRG1) protein, and as antigen in the screening and characterization of these antibodies.

Example 4: Antibody Generation

Polyclonal antibodies: Rabbit polyclonal antisera were raised against five synthetic polypeptide sequences derived from the RG1 protein sequence. These sequences were selected because of their predicted positions at the surface of the protein, in order to generate antisera that are more likely to recognize surface epitopes. Cysteine residues were replaced with aminobutyric acid (Abu) to aid synthesis. The specific amino acid sequences, positions on the RG1 protein and designations for the five peptides are listed below.

Designation	Position	Amino Acid Sequence
1C	28-46	PLGGESICSAGAPAKYSIT (SEQ ID NO: 8)
2C	46-64	TFTGKWSQTAFPKQYPLFR (SEQ ID NO: 9)
3C	77-91	HSSDYSMWRKNQYVS (SEQ ID NO: 10)
4C	188-210	DAGTDSGFTFSSPNFATIPQDTV (SEQ ID NO: 11)
5C	263-274	NEIVDSASVPET (SEQ ID NO: 12)

Peptides were covalently coupled to keyhole limpet hemocyanin (KLH), via an additional carboxyl- terminal cysteine, for use as an immunogen. Similarly, a bovine serum albumin (BSA) conjugate was prepared for the analysis of antisera titers via ELISA.

Two animals were immunized with each peptide. Initial immunizations were performed in Freund's complete adjuvant (0.5 mg/animal), followed by boosts at three week intervals with 0.25 mg/animal in Freund's incomplete adjuvant applied intramuscularly. Periodic test bleeds were taken and antibody titers against the specific BSA- peptide conjugate were measured by ELISA and compared

with preimmune sera. Antisera against peptides 1C and 3C were shown to be active. Antisera against peptide 2C did not recognize RG1 polypeptide. Antisera against peptides 4C and 5C were not tested.

Monoclonal antibodies: Monoclonal antibodies against RG1 were generated by immunizing transgenic mice against RG1 peptides and a 6-histidine-tagged RG1 fusion protein expressed in *E. coli*.
5 Splenocytes of these animals were fused with myeloma cells to produce hybridoma cells. The resulting hybridomas were screened by ELISA for hybridomas producing antibodies directed against RG1 peptides and protein.

Human monoclonal antibodies with specificity for native RG1 were also prepared by immunization of transgenic mice that contain disrupted mouse heavy and mouse kappa light chain loci.
10 (U.S. Patent No. 5,877,397). Transgenic mice from C57BL/6J inbred strains (Medarex) were immunized with purified RG1 protein produced in a stable, transfected BHK cell line (see Example 3).

The antigen was mixed with Complete Freund's (Sigma, F5881) adjuvant for the first and second immunization for protocol one; thereafter the antigens were mixed with Incomplete Freund's (Sigma, F5506). For the second protocol Complete Freund's was used for the first immunization and
15 thereafter Incomplete Freund's was used. Each mouse received 25 µg native RG1 (nRG1) in 100 µL PBS, mixed 1:1 with the adjuvant using an emulsifying needle. Mice are injected with 0.2 mL prepared antigen into the peritoneal cavity.

Hybridoma Preparation: The P3 X63 ag8.653 myeloma cell line (ATCC CRL 1580, lot F-15183) was used for the fusions. The original ATCC vial was thawed and expanded in culture. A seed stock of
20 frozen vials was prepared from this expansion. Cells are maintained in culture for 3–6 months, passed twice a week. Supernatant from P388D1 (ATCC, TIB-63 FL) cells was used as conditioned media for the hybridomas. Briefly, cells were grown and expanded to 200 ml. Stationary cultures were grown for ~7 days. The exhausted supernatant was spun down and filtered through a 0.2 µm sterile filter. This cell line is passed for 3-6 months and then a new vial is thawed.

25 DMEM (Cellgro# 10013271, 10013270) containing 5% FBS (Hyclone, #AKE11828), and P/S (Cellgro, #30002029) and were used to culture the myeloma and P388D1 cells. Additional media supplements were added to the Hybridoma growth media, which included 5% Origen - Hybridoma Cloning Factor (IGEN, # 36684, 36908), 5% P388D1 conditioned media (11/15/00, 12/21/00 DH), 10% FCS (Hyclone, #AKE11828), β-mercaptoethanol (Gibco #1076640), Genetacin (Gibco #1079874),
30 Hepes (Cellgro-#25060041) and HAT (Sigma, H 0262; 1.0×10^{-4} M Hypoxanthine, 4.0×10^{-7} M Aminopterin, 1.6×10^{-5} M Thymidine), or HT (Sigma, H0137; 1.0×10^{-4} M Hypoxanthine, 1.6×10^{-5} M Thymidine).

The splenocytes were fused with myeloma cells using PEG and standard methodology. The resulting hybridomas were plated out into 50 96-well plates, seeded at 200 µl/well for the first fusion.

35 The initial ELISA screen for human IgG, κ antibodies was performed 10-12 days post fusion. Human IgG, κ positive wells were then screened by a 6-His capture ELISA. This screening led to the isolation of 8 human antibodies from 3 fusions: three IgM, one IgG3, and four IgG1 subclass antibodies.

Hybridomas from wells with antigen binding antibodies were first transferred to 24 well plates, and re-screened again for specificity. Native RG1 specific hybridomas were subcloned by limiting dilution to assure monoclonality. Hybridomas producing antibodies that bound native RG1 (nRG1) were preserved at several stages in the development process by freezing cells in IGEN freeze media. Media from these lines was frozen and used for purification of antibodies as described below. Four of the eight were determined to have sufficient specificity to warrant further study.

Purification of antibodies: Four of the human monoclonal antibodies to RG1 described above were purified from cell conditioned media using Protein G Sepharose affinity chromatography. Cells were removed from media by centrifugation and filtration, the media was passed over the Protein G column. The column was then washed in PBS to remove unbound material. Bound antibodies were eluted with 100mM glycine, pH 2.5 and immediately neutralized by adding 10% v/v 1M Tris, pH 8 to the fractions. Fractions containing antibody were pooled, dialysed into PBS, tested for purity by SDS PAGE, and assayed for antigen binding activity by ELISA.

Screening of Antibodies: Screening of antibodies was performed using several different assay procedures:

A. hIgG γ k ELISA Screen: Ninety-six well microtiter plates (Falcon, #3912) were coated overnight with 1ug/ml anti-human IgG γ k or anti-human IgG γ k in PBS (50 ul/well). Plates were aspirated and blocked with PBS 0.05% Tween 20 containing 5% chicken serum for 1 hour at room temperature (100 μ l/well) then washed three times with PBS-tween. Hybridoma supernatants were diluted 1:2 in blocking buffer and incubated for 1 hour at room temperature (100 μ l/well) for screening. Following incubation, the plates were washed three times in blocking buffer prior to adding 100 μ l/well of secondary antibody (HRP anti-human IgGFc (Jackson, #109-036-098 or HRP anti-human IgG γ k(Sigma, #A-7164). The secondary antibody was incubated for 1 hour at room temperature and then the plates were washed 2X in blocking buffer. Plates were developed using 10 ml citrate phosphate buffer, pH 4.0 containing 80 ul ABTS (Sigma, #A1888), 8 μ l H₂O₂ per plate and read at A₄₁₅₋₄₉₀ nm.

B. RG1 Binding ELISA: Ninety-six well microtiter plates were coated overnight with 0.5 -1.0 ug/well purified native RG1 protein in PBS, 50 ul/well, 4 degrees C. The wells were aspirated and then the reaction was blocked with the addition of 100 ul/well PBS-tween + 5% chicken serum, followed by incubation for 1 hour at room temperature. Plates were then washed 3 times in blocking buffer. Serially diluted samples (serum, hybridoma supe, purified mabs etc.) were then added to each well, at 50 ul/well. Incubate 1 hour at room temperature then wash 3 times in blocking buffer. The wells are then incubated with HRP anti-human IgGFc secondary antibody in blocking buffer for 1 hour at room temperature and then washed 3 times as before. Plates are developed using substrate described above and measurement of the A₄₀₅ nm using a 96 well plate reader.

C. Capture ELISA Method: In order to determine mab binding to RG1 protein in its native conformation, a capture ELISA format was used. RG1 protein, containing a six histidine expression tag (6His-RG1), was expressed in BHK cells and used as the antigen. The 6His-RG1 was purified from

conditioned media using NiNTA agarose affinity chromatography following standard methodology.

Purified 6HisRG1 was captured on 96 well NiNTA plates (Qiagen NiNTA HisSorb) using a concentration of 1.5 ug/ml in PBS plus 0.2% BSA(PBS/BSA, 100 ul/well) overnight at 4 degrees C. Wells were washed 3 times with PBS containing 0.05% Tween 20 (PBST). Samples (hybridoma supernatant, sera, purified mabs etc.) were diluted in PBS/BSA and incubated on plates for 1-2 hours at room temperature (50 ul/well) and then washed 3 times with PBST. Secondary antibody (HRP-labeled goat anti-human IgGFc) was diluted 1:5000 in PBS/BSA, added to the plate at 50 ul/well and incubated for 1 hour at room temperature.

Plates were washed 3 times with PBST and developed as in an ELISA. Absorbance at 405 nm was measured using an ELISA plate reader.

D. BIAcore Surface Plasmon Resonance (SPR) Assay: Parental hybridoma supernatants were further screened to qualitatively rank clones by avidity using SPR. A rabbit anti-human IgGFc (Pierce, 31142) was immobilized onto the sensor chip (Biacore, BR-1000-12) using standard amine coupling and 60 ug/ml antibody in acetate pH 4.0 and a mobile phase of HEPES buffered saline (HBS).

Hybridoma media was passed over the surface at 5 ul/min to capture onto the surface and then washed to baseline with HBS. Purified, native, BHK-RG1 protein (400 nM) was then passed over the surface and binding was measured by SPR. At the end of the injection, HBS was passed over the surface to measure dissociation of the antibody:RG1 complex. The slope of the SPR measurement over time is indicative of the dissociation rate, the greater the slope, the faster the off rate and therefore the lower avidity of the antibody.

Example 5: Western blot analysis of antibodies

Antisera were tested for RG1 specificity via Western blotting. RG1 specific antisera (those raised against sequences 1C and 3C, above) were tested on RG1 transiently expressed in COS cells, native RG1 secreted from LNCaP cells and RG1 produced from transfected baby hamster kidney cells (BHK). RG1-specific antisera were further tested on lysates prepared from: LNCaP tumors, LNCaP cells, PC3 tumors, PC3 cells and several clinical samples of human prostate tumors. Cells and tissues were lysed in detergent buffer. After boiling for 5 min, 10 ul of each lysate was loaded onto a 12% SDS-polyacrylamide gel to resolve proteins. Separated proteins were then transferred to nitrocellulose membranes. Binding specificity of RG1 antibodies was verified by binding in the presence of the homologous and heterologous peptides. RG1-specific antisera could detect the protein in all samples but PC-3 cells and PC-3 tumors.

Western blot analysis of human mabs specific for native RG1 demonstrated that these antibodies recognized RG1 on blots only under non-reducing conditions. This suggested that these mabs bind to a more native form of RG1.

Example 6: Purification of Native RG1 Protein Secreted from LNCaP Cells

LNCaP cells grown in culture were shown to secrete native RG1 protein by Western blot analysis. In order to purify the native protein, cells were grown for 48 hours in media lacking serum.

- 5 This serum-free conditioned media was harvested, centrifuged to remove any cells, and concentrated approximately fifty-fold by ultrafiltration. The concentrated media was then diluted ten-fold with 20 mM sodium acetate buffer, pH 6.5 and loaded onto a Q-Sepharose anion exchange column. Column elution consisted of a sodium chloride gradient (0.5% per minute) while collecting 2.0 ml fractions. The RG1 protein eluted at approximately 75 mM NaCl as determined by Western blot and SDS PAGE. The
- 10 native RG1 protein runs at a slightly lower molecular weight than the 6 histidine-RG1 fusion protein expressed in bacteria, presumably because it lacks the fusion peptide.

Example 7: Immunohistochemical staining of RG1 Expression in Prostate and Prostate Cancer Metastasis

15

The expression of RG1 protein was determined by LifeSpan Biosciences, Inc. in a variety of human tissues, including kidney, lung, pancreas, muscle, brain and prostate, as well as lymph node and bonemetastasis. Additional prostate tissues were obtained from the Urology Department at Stanford University School of Stanford and tested at Berlex. The tissue sections were deparaffinized using

20 standard procedures. The polyclonal antibody RG1-3C was used as a primary antibody and the detection system consisted of using Vector ABC-AP kit (AK5002) with a Vector red substrate kit (Sk5002). As a negative control, the staining was carried out in the absence of the primary antibody.

- Expression of RG1 was examined in prostate tumor and normal prostate tissue from several patients. In all cases, strong staining, representing RG-1 expression, was seen in the prostate tumor
- 25 samples. RG-1 expression varied in the normal prostate tissue, from almost none to significant staining.

Expression of RG1 was also detected by immunohistochemistry in lymph node and bone samples known to contain prostate tumor metastasis. Normal lymph node or bone do not show staining.

Example 8: Sequencing of RG1 Antibodies

30

The nucleic acid sequences of two human RG1 antibodies (C and B) generated and purified as described above in Example 4 were determined by standard methods. The nucleotide sequence of the B light chain variable region is designated SEQ ID NO: 20 and that of the B heavy chain variable region is SEQ ID NO: 21. The nucleotide sequence of the C light chain variable region is designated SEQ ID NO:

35 23 and that of the C heavy chain variable region is SEQ ID NO: 24.

The corresponding predicted amino acid sequences of these variable chain regions were determined, and are designated SEQ ID NO: 26 (B light chain); SEQ ID NO: 27(B heavy chain);

SEQ ID NO: 29(C light chain); SEQ ID NO: 30(C heavy chain). See Figures 9 and 10.

Example 9: Determination of Binding Constants for RG1 Antibodies

Kinetic constants (K_D , k_a and k_d) of mab binding to native RG1 protein were determined by BIAcore using a capture format in which soluble, native RG1 protein was bound to immobilized mab on a sensor chip. ImmunoPure rabbit anti-human IgGfc (Pierce, 31142) was covalently immobilized to the Sensor Chip CM5 (Biacore, BR-1000-12) using standard amine coupling methods. 100 ug/ml antibody diluted in 10 mM acetate, pH 4.0 was used at 5 ul/min. HBS-EP (Biacore, BR-1001-88) was used as mobile phase. Unreacted sites were blocked with ethanolamine. Mabs were diluted to 200 nM with HBS and 50 ul was injected per cycle at 10 ul/min. Serial dilutions of BHK-RG1 (12.5 - 400 nM) were bound to the immobilized mab. Dissociation kinetics were measured immediately after the antigen injection was completed at 20 ul/min for 8 minutes. The surface was regenerated following each cycle using 25 ul of 10 mM glycine, pH 1.8 and then washed with HBS.

Typically, five concentrations and a media control were run. Data were fit to a 1:1 Langmuir model using the software provided by the instrument manufacturer (BIAevaluation 3.0), and kinetic constants were calculated. Equilibrium constants were in the nanomolar range with favorable dissociation rates (10^{-4} s^{-1}). Table 1 shows the kinetic constants for 4 of the human antibodies.

Table 1: Kinetic constants of human RG-1 antibodies A, B, C, and D. The kinetic constants for these antibodies were determined by fitting a 1:1 Langmuir model to the data obtained from the BIAcore study. K_a : association rate (1/s); k_d : dissociation rate (1/s), K_D : affinity (M)

M ab	K_a (1/M s)	K_d (1 / s)	K_D (M)
A	2.3×10^4	1.9×10^{-4}	8.9×10^{-9}
B	2.9×10^4	2.3×10^{-4}	8.4×10^{-9}
C	2.5×10^4	8.4×10^{-4}	3.36×10^{-8}
D	3.17×10^4	2.95×10^{-3}	9.27×10^{-8}

Example 10: Radiolabeling of RG1 Antibodies

Conjugation of chelator to RG1 antibodies: The bifunctional chelator p-SCN-Benzyl-DTPA (Macrocyclics, Inc.) was covalently attached to antibodies using a method adapted from Nikula et al, *Nucl. Med. Biol.*, Vol. 22, No. 3, pp. 387-390, 1995. All reagents and equipment utilized during this procedure were rendered metal-free prior to use in order to avoid inactivation of the chelator. All solutions were

prepared with low metal reagents, high purity (MilliQ) water and Chelex treated to remove trace metals. All equipment was rinsed with 10 mM EDTA and then extensively rinsed with MilliQ water.

Purified mabs (~20 mg) were first treated with 1 mM EDTA for 1 hour at room temperature to remove any metals prior to buffer exchange into 50 mM Carbonate buffer, 150 mM NaCl, pH 8.5 using a Pharmacia 26/10 desalting column on an AKTA chromatography system. Antibody containing fractions were pooled and concentrated to approximately 2 mg/ml by ultrafiltration (Centricon 30). A 100 mg/ml p-SCN-Benzyl-DTPA stock solution was freshly prepared in anhydrous DMSO. A 50-100 fold molar excess of DTPA was used in the conjugation reaction, which was allowed to proceed overnight at room temperature. The reaction mixture was then buffer exchanged into 50 mM Na Acetate, 150 mM NaCl, pH 6.5 (Radiolabeling Buffer) and concentrated to at least 3 mg/ml by ultrafiltration. Antibody conjugates were stable in this buffer for weeks at 4 degrees C. Protein concentration was determined by BCA and antigen binding activity was verified by ELISA.

Radiolabeling of RG1 antibodies: DTPA-conjugated antibodies were radiolabeled with ^{90}Y or ^{111}In , under metal-free conditions, for use in in vivo studies in tumor-bearing animals. Typically, 10 mg of antibody conjugate was mixed with 10 mCi of $[\text{}^{90}\text{Y}]\text{Cl}_3$ or $[\text{}^{111}\text{In}]\text{Cl}_3$ (PerkinElmer Life Sciences) for 1 hour at room temperature with gentle mixing behind heavy shielding. EDTA was added to 1 mM and incubated for 10 minutes at room temperature. The reaction mixture was run over a Pharmacia 26/10 Desalting column, that had been preequilibrated in metal-free PBS, in order to separate the radiolabeled antibody from unbound ^{90}Y and to exchange buffer. One ml fractions were collected and antibody containing fractions were pooled. Protein concentration was determined by BCA. Total radioactivity in a 1 ul sample was determined using a liquid scintillation counter for ^{90}Y or a gamma counter for ^{111}In . Specific activity was calculated as mCi per mg of protein, and typically ranged from 0.25 to 1.0 mCi/mg. Radiological purity was determined by instant thin layer chromatograph (ITLC) according to Nikula et al, *Nucl. Med. Biol.* 22: 387-390, 1995. Typically, greater than 98% of the radioactivity was associated with the protein. Antigen binding activity of the radioconjugate was determined by ELISA against an unconjugated antibody standard (^{90}Y conjugates), or using a solid phase radioimmune binding assay on immobilized RG1 protein (^{111}In conjugates). In all cases, antigen binding of the radioconjugates was indistinguishable from that of the unconjugated antibody.

Example 11: Tumor Specific Accumulation of ^{111}In -labeled RG1 Antibodies

Tumor xenografts were established by s.c. injection of 1×10^7 LNCaP cells in matrigel into the flank of 5-6 week-old male athymic nude mice. Biodistribution studies were performed when the tumors reached a volume of 150-400 mm^3 (approximately 4-6 weeks after tumor cell inoculation). ^{111}In -labeled human RG1 antibodies (C, B, A) and a non-specific human IgG₁ control antibody (specific activities, 0.3mCi/mg) were administered intravenously into four groups of 12 mice bearing LNCaP xenografts. Mice were exsanguinated by cardiac puncture prior to dissection. Blood, tumor and all major organs were

removed, weighed on an analytical balance, and the radioactivity was counted in a gamma-counter. The whole body clearance was determined by summing the radioactivity measured in blood, individual organs, and in the remaining carcass. All data were corrected for radioisotope decay. Results were expressed as percentage injected dose per gram of tissue. RG1 specific antibodies show a high tumor specific accumulation (See Figure 7).

Example 12: Tumor Growth Inhibition with ^{90}Y -labeled RG1 Antibodies

Tumor xenografts were established by S.C. co-inoculation of 1×10^7 LNCaP cells in matrigel into the flank of 5-6 week-old male athymic mice. Treatment was initiated when the tumors reached a volume of $50\text{-}350 \text{ mm}^3$ (5 weeks after tumor cell inoculation). Tumor bearing animals were evenly distributed into four treatment groups ($n=13/\text{group}$). A single i.p. injection of radiolabeled antibody B, C, and non-specific IgG₁ ($125 \mu\text{Ci}/\text{animal}$) was administered into mice bearing LNCaP xenografts. The fourth treatment group was given a saline i.p. injection. The effect of ^{90}Y labeled RG1 specific antibodies on the growth of the LNCaP-derived tumors was monitored for 32 days after injection. At that time, animals were sacrificed and tumors were taken out and weighed. Health status was determined by monitoring body weight. A single administration of ^{90}Y labeled specific human RG1 antibodies produced a significant inhibition of tumor growth when compared to the results seen in the animals injected with ^{90}Y labeled nonspecific antibody or the vehicle control. (See Figure 8).

Example 13: Cloning and Expression of RG1 antibodies in CHO Cells

Mutagenesis: Site-directed mutagenesis of the wild-type cDNA encoding variable regions of anti-RG1 antibody B and C was carried out to generate allotypes that are more frequently expressed in humans. The QuickChange® Multisite-directed Mutagenesis method (Stratagene) was used to conduct the mutagenesis, with TOPO/BVH and TOPO/CVH (Medarex) as templates. Primers (GGGGAGGCTTGGTACAACCTGGGGGGTCCCTGAG; SEQ ID NO: 14) and (GAACAGCCTGAGAGCCGAGGACACGGCTGTGTATTACTGTGCAAG; SEQ ID NO: 15) were used to introduce the point mutations H13Q, M90T and M92V into B cDNA (BVH_3m); and H13Q, M90T into C cDNA (CVH_2m). Mutations were confirmed by DNA sequence analysis and resulted in the mutant heavy chain variable regions with sequences of SEQ ID NO: 22 and SEQ ID NO: 25, respectively. The predicted amino acid sequences for these two heavy chain variable regions are given by SEQ ID NOS: 28 and 31, respectively.

Construction of expression vectors: The expression vector of pIE_SRY1fa (Medarex) contains cDNAs encoding CH and CL regions of human IgG1 (fa haplotype) and kappa chains, respectively. To allow for in frame cloning of B and C light chain variable regions into pIE_SRY1fa was , the primer pair BVK_F (GGGAAGCTTGCCACCATGGAA ACCCCAGCG; SEQ ID NO: 16) and BVK_R

(CAGTCCGTACGTTT GATCTCCACCTTGGTCC; SEQ ID NO: 17) was used to introduce compatible HindIII/Bsiw sites (under line) at the 5' and 3' ends, respectively, of BVL and CVL cDNA. The resulting PCR-generated VL cDNAs were cloned into the HindIII/Bsiw site of pIE_SRY1fa to create pIE/BVL and CVL. The same strategy was used for constructing in frame VH fusions (including BVH, BVH_3m, CVH and CVH_2m) into pIE/BVL and CVL. Briefly, the primer pair of CVH_F (GTCAGGATGCGGCGCCACCATGGAGTTTGTGCTGAGCT; SEQ ID NO: 18) and CVH_R (ACCGATGGGCCCCTTGGTGA; SEQ ID NO: 19) was used to introduce NotI/ApaI sites at the ends of PCR-amplified VH cDNA. The PCR products were digested with NotI/ApaI and inserted upstream of the CH region of pIE/BVL and pIE/CVL ensuring that the VH regions were in frame with CH region in the respective pIE derivatives. The final constructs were named pIE/B, pIE/B_3m, pIE/C and pIE/C_2m. All inserts have been verified by DNA sequence analysis.

Transfection and selection/amplification of DG44 and DXB11 cells. About 4×10^6 DG44 and DXB11 cells supplemented with F12 medium and 5% FCS were plated on P100 dishes one day before transfection. Transfections were carried out using Lipfectamine 2000 (Invitrogen) and 24 µg linearized plasmid DNA (pIE/B_3m or pIE/C_2m) /P100. The medium was changed 4 hours after transfection. Selective conditions were applied approximately 24h post-transfection.

Selection was first carried out with MEM medium containing 5% dialyzed FBS, 2mM L-glutamine and G418 (400ug/ml), but lacking ribonucleosides and deoxyribonucleosides. Reaching a confluency of about 90% cells were split into 4 x P100 dishes and co-selected with G418 plus methotrexate at various concentrations. After one week, the surviving cells were plated into 96-well plates at 100-cells/ plate in the presence of co-selection medium. Surviving clones were screened by ELISA for expression of recombinant antibody. Gene copy number of 10 clones exhibiting the highest expression levels was amplified by consecutive selection in the presence of increasing concentrations of methotrexate and chosen clones adapted to serum free medium for preparation of a master cell bank.

All publications and patents mentioned in the above specification are herein incorporated by reference. While the present invention has been described with reference to the specific embodiments thereof, it should be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation, material, composition of matter, process, process step or steps, to the objective, spirit and scope of the present invention. All such modifications are intended to be within the scope of the claims appended hereto.